AGRICULTURAL ARITHMETIC

SHUTTS AND WEIR

Agricultural Arithmetic

BY

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FOREWORD

Arithmetic, as a subject in the school curriculum, is of no particular value in itself. It is not one of the satisfactions of life. It was so regarded, however, in the past, and much pleasure to the keen witted, as well as sorrow of soul to the dull, was wrought by its puzzles which certainly did not grow out of any of the occupations of man. But tradition is so strong that it has taken a long time to eliminate this theory concerning arithmetic with its attendant conundrums.

Arithmetic is best regarded as an instrument, a tool, with which to accomplish various desired ends and hence should be studied in adaptation to those ends.

Facility in the use of arithmetic depends upon two things: first a knowledge of the business relations to which it is to be applied, and, second, a knowledge of the pure arithmetical processes together with skill in performing them. Hence this book has been organized into two parts.

In Part I has been gathered into a brief space the essential things to be considered and drilled upon to enable one to develop accuracy and rapidity in computation by arithmetical processes. As it presupposes a considerable knowledge of the processes of arithmetic, Part I does not attempt to develop fully the general subject, but is simply a rational review to strengthen some of the weak points.

Part II is an application of arithmetic to farm experiences. The problems are not inventions, but are drawn from life in its various phases upon the farm. Necessary conditions in problems are sometimes omitted in order that the pupil may collect his own data from observation, experience, etc., at home; hence results will differ or only

approximate one another. These varying results will naturally lead to a study of the causes that produce them, and thus may supply an incentive to improve unfavorable conditions.

Lack of space has limited the number and a greater variety of problems. It is hoped that the teacher will formulate additional problems to give a further drill on points not fully understood by the respective classes or individuals.

Farm operations have been determined too largely by tradition; and the prejudice against scientific methods has been so strong that progress has been slow. It is believed that the study of topics and selection of problems herein will prove an incentive for improvement.

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PART ONE

INTRODUCTION

To satisfy his wants in his conquest over matter, civilized man, or even the savage, needs to determine the size of the elements with which he deals. To do this he must select a part of the whole, an amount with which he is familiar, and by this estimate or measure the size of the whole.

Mass or magnitude is the simple notion of size. It is indefinite and always suggests the question, How much?

Measurement is the process of determining how much there is of the magnitude. The process of measurement consists in determining the number of units it contains.

A unit is a single thing or a portion of a magnitude into which it is divided in the process of measurement.

Number tells how many units there are in a given mass or magnitude.

Quantity is the complete answer to the question how much there is of the mass or magnitude that is measured.

To illustrate: A person desires to know how large is a given piece of land. He takes a plat of land of a given size and calls it, for instance, a square rod. In the fundamental way of measuring, he separates the land into square rods and counts them. His result, say, is 15 square rods. The *magnitude* is the amount of land that prompts the question, How much? The *unit* is the square rod, the portion into which the whole is divided in the process of measurement. The *number* is 15, and tells how many rods there are. The *quantity* is 15 rods and tells the size of the

magnitude. The *measurement* is the whole process of division and counting by which the quantity is determined.

Any process, however complicated, by which any magnitude can be expressed as quantity is called measurement. Usually short methods are used; as, I wish to know the length of a board or a fence. I use a tool that has been invented for the purpose, namely a rule or tape line, and lay it along the board or fence and read the result of somebody else's counting marked upon it. In the case of the land, we have learned by study and experience that the process of division and counting can be shortened, if the land is rectangular in form, by measuring two adjacent sides and multiplying together the results. (Page 32.)

Measurement, in its simplest and probably its earliest form, consists simply in counting. One desires to know the size of a flock of sheep. The natural unit is the individual animal; hence a division of the flock is not made, and the process of measurement consists simply in counting. But even here experience suggests that the counting can be done more rapidly if the flock is divided into groups of two, four, or some other number for a unit, and these groups counted. It is said that, when Xerxes wanted to know the size of the army with which he tried to conquer Greece, he drove his men into pens holding ten thousand each, and counted the pens.

The subject of arithmetic can be more easily understood, if it can be appreciated that in all its essential processes it grows out of and in reality is, in all its details, but a continuation or an application of the results of the process of measurement. The unit in its relation to number must not be lost sight of, or, as too often happens, arithmetic becomes a maze, a labyrinth in which the pupil is hopelessly lost.

Arithmetic has been called the science of numbers and

the art of computation. It is rather the science of measurement. It deals with quantity and number; and consists of the processes of reduction, combination, and division of quantity and number so as to express the results of measurement in the best forms for man's use.

This book deals with arithmetic in so far as it relates to man's needs in the occupation of agriculture.

Part I is intended as a review of the essentials to prepare for the treatment of agricultural arithmetic in Part II. Some topics of arithmetic are omitted, and others are treated with more or less assumption of knowledge of the subject on the part of the student.

REVIEW OF ESSENTIALS

ADDITION

Facility in addition depends upon a thorough memorizing of the addition table.

Step 1. The addition table consists of forty-five combinations; viz., the sums of all possible pairs of digits. Leaving out the combinations with 1, there are but thirty-six to memorize; as,

2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	4	4	4
2	3	4	5	6	7	8	9	3	4	5	6	7	8	9	4	5	6
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
4	4	4	5	5	5	5	5	6	6	6	6	7	7	7	8	8	9
7	8	9	5	6	7	8	9	6	7	8	9	7	8	9	8	9	9
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

One should not be satisfied with results when committing these combinations to memory until any given combination is a symbol for the sum; as, $\begin{matrix}8\\9\\\hline\end{matrix}$ should suggest to the mind seventeen rather than 8 and 9. These combinations are similar to words in reading; as, for example, when one sees the symbol "lion" he thinks of the meaning of the word lion rather than the separate symbols "l-i-o-n."

Step 2. In learning the addition table, drill much on combinations of numbers of two orders and a digit; as,

17	54	37	26	24	36	48	29
9	8	6	5	7	3	7	4
—	—	—	—	—	—	—	—

and the addition of numbers from 11 to 18 inclusive to larger numbers of two orders; as,

28	34	46	79	63	57	85	91
12	17	15	18	13	16	14	19
—	—	—	—	—	—	—	—

The former group is necessarily involved when a column of figures is being added; the latter, in more rapid addition.

3
7
5
9
4
6
8
7
3
4
7
9
5
6

Thus, if the combinations of the addition table have been learned and facility in Step 2 acquired, the column can be added doubly fast.

In adding up the column at the left, one sees eleven in 6 and 5, then sixteen in 9 and 7, and thinks 27; then seeing seven in 4 and 3, thinks 34; then 49, 59, 73, 83 in order. Adding downward, he sees the sums in order: 10, 24, 34, 49, 56, 72, 83.

Thus addition depends (1) upon a quick recognition of the thirty-six elements of the addition table, and (2) facility in applying them.

Additional drill material should be supplied and utilized until facility is acquired. See page 39, note.

SUBTRACTION

Subtraction is the process of finding how much greater one of two numbers is than the other; as, $8-3=5$, means that eight is five greater than three.

The answer in subtraction is the *difference*, or *remainder*.

The greater number is the *minuend*.

The lesser number is the *subtrahend*.

Facility in subtraction depends upon skill in recognizing what digit added to another digit will produce a given number; as, 8 and what are 12? 6 and what are 13?

Find the difference between 3,426 and 9,878.

9878
3426
6452

SOLUTION: 6 and 2 are 8; 2 and 5 are 7; 4 and 4 are 8; 3 and 6 are 9.

Subtract 3,623 and 1,747

3623
1747
1876

SOLUTION: 7 and 6 are 13; 5 (one to carry) and 7 are 12; 8 (one to carry) and 8 are 16; 2 and 1 are 3.

Subtract 30,000 and 93

30000
93
29907

SOLUTION: 3 and 7 are 10; 10 and 0 = 10; 1 and 9 = 10
1 and 9 = 10; 1 and 2 = 3.

The process is the same as in adding the subtrahend to the remainder. The merchant in making change subtracts in the same way.

The advantage of this method is that one utilizes one's knowledge of the addition table instead of learning a new table, and hence economizes energy. There are many methods of "borrowing" in subtraction, but experience has demonstrated beyond the possibility of a doubt that the addition method is the easiest to learn and the most rapid in practice. Pupils should drill until they are skillful in this work.

MULTIPLICATION

Facility in multiplication depends upon a quick application of the multiplication table. Hence it is necessary that the combinations of the multiplication table be known at sight. (The table on page 12 constitutes the multiplication table, if the numbers are used as factors.) The addition and multiplication tables should never be taught together; for confusion may arise. The subtraction form of the addition table and the division and factoring forms of the multiplication table make excellent drills for the respective tables, besides being valuable in themselves. (Page 17.)

Sufficient material for drill should be provided to produce efficiency.

DIVISION

Step 1. Provide many exercises upon the division form of the multiplication table, followed by such examples as $18 \div 4$, $63 \div 8$, $42 \div 5$.

Step 2. Application of Step 1 in short division with the usual form: 6)2573

428-5

Step 3. Long division in the following form:

Two essentials should here be observed: the proper placing of the first figure of the quotient, and facility in the use of the trial divisor.

The first figure of the quotient should be placed directly over the last figure of the first partial dividend and the other figures should follow in order. The value of this method will be seen in division of decimals. (Page 41.)

```
  865
31)26834
   248
   ---
   203
   186
   ---
   174
   155
   ---
    19
```

Much drill will be needed in acquiring facility in estimating the quotient figures by means of a trial divisor. The larger the second figure from the left of the divisor, the more allowance must be made for carrying in multiplying by the quotient figure. When the second figure is 6 or more, it is usually better to use the first figure plus one for the trial divisor. As, in dividing 9,376 by 387, try 4 into 9, in estimating the quotient figure.

CHECKING OR PROVING

Mistakes due to careless figuring are costly in any business. He is a poor business man indeed who does not check his figures carefully before acting upon them. Confidence and reliability arise from the habit of proving the correctness of one's own work, not in depending upon others. A person can be instructed wherein he is ignorant, but the careless habit is fatal.

Addition is usually checked by adding the column in the opposite direction. The two sums should tally.

Subtraction is best checked by adding the subtrahend and remainder and noting whether the sum tallies with the minuend.

Checks for Multiplication.

Multiplication may be checked by (1) reviewing the work; (2) dividing the product by one of the factors and noting whether the quotient agrees with the other factor; (3) "casting out nines." The latter is the shortest and best method. In teaching, select one of the checks and omit the others.

In the process of casting out the nines from a number, drop from the sum of the digits a nine whenever nine is reached in the process of addition.

Cast out the nines in 4,379,326.

SOLUTION: $4 + 3 + 7 - 9 = 5$. $5 + 3 + 2 - 9 = 1$. $1 + 6 = 7$. The remainder is 7. Or, beginning at the right, drop 6 and 3, the 9 and 2 and 7 which leaves the remainder of $3 + 4$ or 7. As a check in multiplication, cast out the nines in each factor and out of the product of the remainders thus obtained. Note whether the result agrees with the remainder after casting out the nines of the product of the multiplier and multiplicand.

As, in the above example, the remainder for the multiplicand is 7, for the multiplier is 3, for 21, the product of 3 and 7, is 3, as the remainder for the product, 2,100,531, is 3, the work is correct.

```
  8863
   237
 62041
 26589
 17726
2100531
```

Checks for Division.

The most common check for division is to multiply the divisor by the quotient, add the remainder, and compare the result with the dividend.

The shortest check for division is the process of casting out the nines.

Cast out the nines in divisor and quotient separately and find the product of the remainders thus obtained and add the division remainder. Cast out the nines from this sum. This remainder should agree with the remainder obtained by casting out the nines from the dividend.

As, $3 \times 3 + 5 - 9 = 5$. The remainder obtained by casting out the nines from the dividend is 5. $5 = 5$. $\therefore$ the division is correctly performed.

```
   3792
21)79637
   63
   166
   147
    193
    189
     47
     42
      5
```

FACTORING

Skill in factoring is helpful in acquiring facility in the solution of many problems. This facility is valuable in

abbreviating the processes in problems involving continued operations of multiplication and division of simple numbers and fractions (called cancellation), least common multiple, computation of areas and contents, and many others. Long processes can sometimes be so abbreviated that the results can be obtained mentally or with but little written work.

A composite number is one that can be divided exactly by some other number than one or itself; as, 18, 36, 152, etc.

A prime number is one that is not exactly divisible by any number except one and itself; as, 2, 7, 29, 37, 101, etc.

A composite factor is a composite number used as a factor; as, 8 is a composite factor of 48; 16 of 96; 6 of 42, etc.

A prime factor is a prime number used as a factor; as, 7 is a prime factor of 42; 11 of 44; 13 of 91, etc.

The essentials for facility in factoring are a memory of the two factors that produce the composite numbers from 1 to 100 and a few numbers frequently used above 100, the squares of numbers from 1 to 20, the cubes of the digits, and the prime numbers from 1 to 100. These tables of combinations should be thoroughly memorized. A part of them can be learned with the multiplication table, and they will serve as an excellent drill in learning that table. (Page 14.)

When the factoring table is learned, any of the above numbers can readily be reduced to prime factors; as,

$72 = 8 \times 9$ (table) $= 2 \times 2 \times 2 \times 3 \times 3$, or $2^3 \times 3^2$.

$96 = 8 \times 12$ (table) $= 2 \times 2 \times 2 \times 2 \times 2 \times 3$, or $2^5 \times 3$

Such facility should be acquired that one can tell at sight the number of times a given factor is found in any number of two orders; as, 24 contains three 2's and one 3; 56 contains three 2's and one 7; 84 = one 7, one 3 and two 2's, etc. Pupils should learn to use the exponential form

for expressing the number of times any given factor is found in a number; as, $8 = 2^3$; $27 = 3^3$; $16 = 2^4$; $64 = 2^6$; $72 = 2^3 \times 3^2$; $28 = 2^2 \times 7$.

If taught to read such an expression as $2^3 \times 3^2$, as 3 factor two's times 2 factor three's, the meaning would be more apparent and the later work in algebra would not prove to be such a puzzle. The subject of factoring is too often ignored. Careful attention to its details will add much to facility in computation in later work.

FRACTIONS

A *fraction* is an expression of number in which the unit is any given part of the unit one.

$\frac{3}{4}$ of a foot means 3 units, each of which is a fourth of a foot; $\frac{2}{3}$ of an apple can be expressed as 2 thirds of an apple, in which 2 is the number and a third of an apple is the unit. (Page 9.)

The *numerator* is the number above the line. It is always in all its relations a number (page 9), and tells how many times the unit, one over the denominator, is taken. In $\frac{3}{4}$, the 3 tells how many times the unit $\frac{1}{4}$ is taken. It is to be dealt with as any other simple number.

The *denominator* is the number below the line, and indicates the unit by telling into how many parts the original unit or one is divided. In $\frac{3}{4}$, the 4 tells that one was divided into 4 equal parts, and, therefore, the unit of the numerator 3 is $\frac{1}{4}$. The number is 3 and the unit is $\frac{1}{4}$, and the expression $\frac{3}{4}$ is a quantity (page 9) which should be thought of and treated like any other quantity. It is in its nature like 3 pints. The denominator 5 indicates that the unit is $\frac{1}{5}$. The denominator 7 indicates that the unit is $\frac{1}{7}$, etc. The fact that its unit is indicated by a denominator, however, makes it appear to be different from other quantities. But by carefully considering its number and unit relations the diffi-

culties in fractions can largely be eliminated. The following comparisons illustrate this idea:

$\frac{3}{4} + \frac{2}{4} = \frac{5}{4}$. 3 pints + 2 pints = 5 pints.
$\frac{3}{4} - \frac{2}{4} = \frac{1}{4}$. 3 pints − 2 pints = 1 pint.
$7 \times \frac{3}{4} = \frac{21}{4}$. 7×3 pints = 21 pints.
One third of $\frac{6}{4} = \frac{2}{4}$, one third of 6 pints = 2 pints.

3 quarts and 2 gallons can be added only by reducing both quantities to the same unit; as, 3 quarts + 8 quarts = 11 quarts; or 6 pints + 16 pints = 22 pints. The answer in either case can be reduced to the desired unit. In adding $\frac{3}{4}$ and $\frac{5}{8}$ the same is true; they can be added only as they are expressed in the same unit. $\frac{3}{4}$ of anything equals $\frac{6}{8}$ of the same thing. Then the addition becomes $\frac{6}{8} + \frac{5}{8} = \frac{11}{8}$.

The same principle holds in subtraction.

To understand the processes of fractions, certain principles need to be established:

Principle I. *If the numerator of a fraction is multiplied or divided by any number, the fraction is multiplied or divided, respectively, by that number.*

This is apparent when one thinks of a fraction as a quantity consisting of a number and a unit. 6 fourths is twice as large as 3 fourths, just as 6 bushels is twice as large as 3 bushels, or 6 units of any kind is twice as large as 3 units of the same kind. In general: *If the numerator is increased, the fraction is increased, if the numerator is diminished, the fraction is diminished.*

Principle II. *If the denominator of a fraction is multiplied or divided by a number, the fraction is divided or multiplied, respectively, by that number.**

$\frac{3}{2 \times 4} = \frac{3}{8}$. To show why $\frac{3}{8}$ is less than $\frac{3}{4}$: $\frac{1}{4}$ means that one was divided into 4 equal parts and one of them

*This principle must be thoroughly worked out and understood, for herein lies the apparent difference between fractions and other numbers.

expressed. $\frac{1}{8}$ means that one was divided into 8 equal parts and one expressed. As the one, or the whole, was divided in the latter case into twice as many parts, each part must be one half as large; therefore, $\frac{1}{8}$ is half as large as $\frac{1}{4}$. Since $\frac{1}{8}$ is half as large as $\frac{1}{4}$, 3 of the eighths must be half as large as 3 of the fourths.

In a similar manner, it can be shown that the fraction is multiplied by a number when the denominator is divided by the number.

In general: *If the denominator of a fraction is made smaller, the fraction is made larger; and, if the denominator is made larger, the fraction is made smaller.*

From these principles the following rules are derived:

Rules: *To multiply a fraction by a number, multiply the numerator or divide the denominator by that number.*

To divide a fraction by a number, divide the numerator or multiply the denominator by that number.

It is always better to divide one of the terms, when the division is exact, than to multiply, as the terms of the resulting fraction will be smaller.

$4 \times \frac{3}{8} = \frac{3}{2}$, or $4 \times \frac{3}{8} = \frac{12}{8} = 1\frac{1}{2}$. $\frac{6}{7} \div 3 = \frac{2}{7}$, or $\frac{6}{7} \div 3 = \frac{6}{21}$, which is equal to $\frac{2}{7}$. It will be observed that the division process in each case is the shorter.

Sometimes one term can be divided by one factor of a number and the other term multiplied by the other factor.

$12 \times \frac{5}{8} = \frac{15}{2}$. The 8 is divided by 4 and the 5 is multiplied by the other factor, 3. See footnote on next page.

$\frac{6}{7} \div 15 = \frac{2}{35}$. 6 is divided by the factor 3 and 7 is multiplied by the other factor. See footnote on next page.

2 × 3 pints = 6 pints, or 3 quarts. In the former result the number was doubled, in the latter the unit was doubled.

$2 \times \frac{3}{4} = \frac{6}{4}$ or $\frac{3}{2}$. In a similar manner in $\frac{6}{4}$ the number, 3, was doubled; in $\frac{3}{2}$ the unit, 1 fourth, was doubled. The result is the same, $\frac{6}{4} = \frac{3}{2}$. The process of operating upon the unit in fractions is different from that in other quantities, but the meaning is the same.*

Principle III. *If both terms of a fraction are multiplied or divided by the same number, the value of the fraction is not changed.*

This is apparent by application of Principles I and II, for to multiply both terms of a fraction by the same number is to both multiply and divide the fraction by that number; hence its value remains unchanged.

The division of both terms can be shown in a similar manner to produce no effect upon the value of the fraction.

$\frac{8}{16} = \frac{4}{8} = \frac{2}{4} = \frac{1}{2}$; $\frac{5}{15} = \frac{1}{3}$; $\frac{3}{4} = \frac{6}{8} = \frac{12}{16}$, etc.

$\frac{4}{5} = \frac{8}{10} = \frac{16}{20}$, etc.

KINDS OF FRACTIONS.

When fractions are classified in relation to the unit one, they are divided into two classes, Proper and Improper Fractions.

Proper fractions are those that are less than one; their numerators are less than their denominators.

$\frac{2}{3}$ is less than one. $\frac{2}{3}$ means 2 of the third parts of one. $\frac{2}{3}$ of an apple means 2 parts of an apple, each a third of one apple. $\frac{3}{5}$, $\frac{9}{11}$, $\frac{5}{7}$, $\frac{8}{9}$, are proper fractions. Why should their numerators be less than their denominators?

Improper fractions are those that are equal to one or are greater than one; their numerators are equal to their denominators or are greater than their denominators.

$\frac{3}{3} = 1$, $\frac{5}{5} = 1$, $\frac{7}{7}$ of a quart = 1 quart. Show why?

*The fact that there are two ways of multiplying or dividing a fraction is not a new idea. By again considering the unit and number signification of the fraction, and comparing with other quantities, the meaning of the processes will be seen to be the same.

$\frac{8}{4}$ of a dollar equals 2 dollars. How much is $\frac{1}{4}$ of a dollar? $\frac{5}{4}$ of a dollar? What is the value of all fractions in which the numerator equals the denominator? Compare such a fraction with one in which the numerator is greater than the denominator. Why, in an improper fraction, should the numerator be equal to or greater than the denominator?

When fractions are classified with relation to their form, they are usually divided into three classes: simple fractions, mixed numbers, and complex fractions.

Simple fractions are those that have one numerator and one denominator; as $\frac{5}{8}$, $\frac{7}{3}$, $\frac{18}{19}$, $\frac{128}{316}$, etc.

Mixed numbers are fractions that are composed of an integer and a fraction; as, $3\frac{2}{5}$, $5\frac{3}{7}$, $1\frac{1}{2}$, $18\frac{2}{3}$, etc.

Complex fractions are those that have a fraction in the numerator or a fraction in the denominator or in both; as,

$$\frac{3\frac{2}{3}}{4}, \quad \frac{\frac{2}{3}}{6}, \quad \frac{4}{3\frac{1}{2}}, \quad \frac{5}{\frac{3}{4}}, \quad \frac{2\frac{1}{2}}{4\frac{2}{3}}, \quad \frac{2\frac{2}{7}}{3\frac{2}{2\frac{1}{4}}}, \text{ etc.}$$

Which fractions are proper fractions in the illustrations given under the classifications according to their forms? Which improper? Classify the following according to form:

$$\frac{18}{\frac{3}{5}}, \quad \frac{325}{17}, \quad 8\frac{2}{7}, \quad \frac{15}{112}, \quad 24\frac{1}{2}, \quad \frac{8\frac{2}{3}}{4}, \quad \frac{16}{7}, \quad \frac{3\frac{1}{2}}{\frac{2}{5}}, \quad \frac{125}{28}, \quad \frac{36}{142}.$$

Classify the above list of fractions in relation to the unit one.

REDUCTION OF FRACTIONS

A fraction is in its *simplest form* when it is a proper fraction with its numerator and denominator prime to each other (i. e., have no common factor), or when it consists of an integer and a fraction in its simplest form.

An answer to a problem should always be expressed in its simplest form, unless the problem specifically states otherwise.

Reduce $\frac{24}{7}$ to its simplest form.

SOLUTION: Since 7 sevenths = 1, 24 sevenths will equal as many ones as 7 sevenths is contained times in 24 sevenths, which is 3 times, with 3 sevenths remaining. Therefore $\frac{24}{7} = 3\frac{3}{7}$.

Reduce $5\frac{3}{8}$ to an improper fraction.

SOLUTION: Since $1 = \frac{8}{8}$, 5 will equal $5 \times \frac{8}{8} = \frac{40}{8}$. $\frac{40}{8} + \frac{3}{8} = \frac{43}{8}$ $\therefore 5\frac{3}{8} = \frac{43}{8}$.

Reduce to improper fractions the following: $7\frac{1}{2}$, $5\frac{3}{8}$, $4\frac{5}{7}$, $17\frac{2}{3}$, $128\frac{3}{4}$, $91\frac{5}{6}$.

Reduce to their simplest form the following: $\frac{17}{3}$, $\frac{15}{6}$, $\frac{13}{4}$, $\frac{128}{9}$, $\frac{24}{8}$, $\frac{21}{7}$, $\frac{162}{8}$, $\frac{356}{16}$, $\frac{512}{64}$.

Reduce $\frac{24}{28}$ to its simplest form.

SOLUTION: As 24 and 28 have a common factor, $\frac{24}{28}$ can be reduced to lower terms by Principle III. $\frac{24}{28} = \frac{6}{7}$.

Reduce the following fractions to lowest terms: $\frac{15}{20}$, $\frac{8}{24}$, $\frac{5}{75}$, $\frac{7}{35}$, $\frac{4}{8}$, $\frac{3}{12}$, $\frac{18}{48}$, $\frac{12}{34}$, $\frac{19}{57}$, $\frac{65}{91}$, $\frac{34}{85}$.

LEAST COMMON MULTIPLE

In order to add or subtract fractions they must be expressed in terms of a common unit; hence a common unit for these fractions must be found. As they cannot be expressed in a common unit of lower terms, they must be reduced to higher terms. Hence both terms of each fraction must be multiplied by such numbers respectively as will make the denominators alike. (Principle III.)

A *multiple* of a number is one that exactly contains the given number.

16 is a multiple of 4 because 16 exactly contains 4. It is also a multiple of 2 and 8.

A *common multiple* of two or more numbers is one that is a multiple of each of them.

24 is a common multiple of 4, 8, and 12. 48, 72 and 96 are common multiples of 4, 8 and 12. Name other common multiples of these numbers.

A *least common multiple* of two or more numbers is the smallest number that is a common multiple of them.

36 is the least common multiple of 4, 6, 9, and 12. Why? Apply the definition.

The process of finding the least common multiple of numbers depends upon the following principle:

Principle: *The multiple of any number must contain each prime factor of that number.*

Any multiple of 24 must contain three factor two's and one three. Any multiple of 36 must contain two factor three's and two factor two's, etc.

To find the l. c. m. of 8, 12, and 15, it is necessary to have the product of 2^3, 3, and 5, which equals 120, for there are 3 two's (factors) in 8, a 3 in 12, and a 5 in 15. ∴ the l. c. m. of 8, 12, and 15 is the product of 2^3, 3 and 5, or 120.

Rule: *To find the l. c. m. of any set of numbers select each prime factor found in them the greatest number of times it occurs in any of them and multiply the factors together.*

If factoring is understood and this rule followed, the l. c. m. of all numbers of one or two orders can be worked mentally.

*Find the l. c. m. mentally of the following:

1. 8, 15, 20.
2. 16, 24, 12.
3. 42, 18, 14.
4. 36, 18, 12.
5. 24, 15, 20, 40.
6. 14, 28, 56, 42.
7. 4, 12, 15.
8. 56, 63, 36, 42.

ADDITION AND SUBTRACTION OF FRACTIONS

Add $\frac{3}{4}$, $\frac{5}{8}$, and $\frac{7}{12}$.

SOLUTION: $\frac{3}{4} = \frac{18}{24}$, $\frac{5}{8} = \frac{15}{24}$, $\frac{7}{12} = \frac{14}{24}$. They can now be added, as they have a common unit; viz. $\frac{1}{24}$. $\frac{18}{24} + \frac{15}{24} + \frac{14}{24} = \frac{47}{24} = 1\frac{23}{24}$.

Subtract $\frac{3}{7}$ from $\frac{4}{5}$.

SOLUTION: $\frac{4}{5} = \frac{28}{35}$. $\frac{3}{7} = \frac{15}{35}$. $\frac{28}{35} - \frac{15}{35} = \frac{13}{35}$.

* This work can be taught and drilled upon while teaching factoring.

Required to add $\frac{2}{5}$, $\frac{3}{4}$, $\frac{7}{10}$. Reduce to twentieths.

$\frac{2}{5} + \frac{3}{4} + \frac{7}{10} = \frac{8}{20} + \frac{15}{20} + \frac{14}{20} = \frac{37}{20} = 1\frac{17}{20}$.

Required to subtract $\frac{1}{3}$ from $\frac{2}{5}$. Reduce to fifteenths.

$\frac{6}{15} - \frac{5}{15} = \frac{1}{15}$.

Such problems should be added or subtracted mentally.

MENTAL PROBLEMS

Add: $\frac{2}{3}$, $\frac{3}{4}$, $\frac{1}{2}$; $\frac{1}{3}$, $\frac{3}{4}$, $1\frac{1}{2}$; $1\frac{5}{6}$, $2\frac{2}{3}$, $3\frac{5}{6}$; $2\frac{3}{4}$, $2\frac{1}{2}$; $\frac{5}{6}$, $\frac{3}{4}$, $\frac{5}{8}$.

$\frac{5}{8} - \frac{7}{12}$; $\frac{7}{2} - \frac{8}{9}$; $4\frac{2}{3} - 1\frac{3}{4}$; $5\frac{3}{8} - 2\frac{7}{12}$; $\frac{9}{10} - \frac{3}{20}$; $8\frac{5}{7} - 3\frac{20}{21}$.

In the following add and express only the answers:

(1)	(2)	(3)	(4)	(5)	(6)
$128\frac{3}{4}$	$196\frac{1}{6}$	$172\frac{7}{12}$	$52\frac{1}{4}$	$27\frac{1}{9}$	$821\frac{1}{3}$
$16\frac{2}{3}$	$216\frac{1}{3}$	$18\frac{1}{2}$	$632\frac{1}{8}$	$387\frac{5}{18}$	$426\frac{2}{5}$
$132\frac{1}{2}$	$81\frac{5}{12}$	$316\frac{2}{3}$	$412\frac{7}{16}$	$24\frac{2}{3}$	$127\frac{2}{3}$
$284\frac{1}{4}$	$36\frac{5}{6}$	$508\frac{11}{12}$	$386\frac{7}{8}$	$498\frac{5}{6}$	$84\frac{3}{5}$
$961\frac{1}{3}$	$183\frac{3}{4}$	$113\frac{5}{6}$	$496\frac{3}{16}$	$346\frac{7}{9}$	$119\frac{4}{5}$
$342\frac{3}{4}$	$14\frac{2}{3}$	$249\frac{1}{4}$	$82\frac{1}{2}$	$27\frac{1}{2}$	$16\frac{2}{3}$

Subtract:

(1)	(2)	(3)	(4)	(5)	(6)
$24\frac{3}{4}$	$136\frac{7}{8}$	$316\frac{5}{12}$	$365\frac{8}{9}$	$1{,}324\frac{5}{6}$	$242\frac{2}{3}$
$16\frac{1}{2}$	$18\frac{3}{4}$	$118\frac{1}{3}$	$113\frac{5}{6}$	$876\frac{1}{12}$	$156\frac{5}{6}$

(7)	(8)	(9)	(10)	(11)	(12)
$356\frac{3}{8}$	$42\frac{1}{4}$	$318\frac{5}{9}$	$412\frac{2}{3}$	$856\frac{3}{10}$	$219\frac{3}{7}$
$138\frac{5}{6}$	$28\frac{5}{6}$	$227\frac{7}{12}$	$319\frac{5}{8}$	$416\frac{3}{4}$	$218\frac{2}{3}$

Special Devices

$\frac{1}{3} + \frac{1}{4}$, $\frac{1}{5} + \frac{1}{8}$.

In similar examples, in which the numerators are 1, by observing the operation it can be seen that one adds the denominators for the numerator and multiplies the denominators for the denominators.

$\frac{1}{3} - \frac{1}{4}$, $\frac{1}{5} - \frac{1}{8}$.

Make a similar rule for subtraction.

$\frac{2}{3}+\frac{2}{5}$; $\frac{5}{6}+\frac{5}{8}$; $\frac{4}{5}+\frac{4}{7}$. To shorten the process, when the numerators are alike, multiply the sum of the denominators by the numerator for the numerator and take the product of the denominators for the denominator; as, $\frac{16}{15}$, $\frac{70}{48}$, $\frac{48}{35}$. Reduce these results to simplest form. $\frac{3}{7}-\frac{3}{8}$, $\frac{2}{3}-\frac{2}{5}$, $\frac{7}{8}-\frac{7}{11}$.

Make a rule for abbreviating the process of subtraction.

Practice for speed in addition and subtraction using the following list; as, $\frac{1}{3}+\frac{1}{5}$, $\frac{1}{7}+\frac{1}{8}$, $\frac{1}{3}-\frac{1}{5}$, $\frac{1}{7}-\frac{1}{8}$, etc. Repeat the process several times.

(1)		(2)		(3)		(4)	
$\frac{1}{3}$	$\frac{1}{5}$	$\frac{1}{4}$	$\frac{1}{7}$	$\frac{2}{3}$	$\frac{2}{5}$	$\frac{3}{5}$	$\frac{3}{8}$
$\frac{1}{7}$	$\frac{1}{8}$	$\frac{1}{5}$	$\frac{1}{6}$	$\frac{3}{7}$	$\frac{3}{9}$	$\frac{2}{5}$	$\frac{2}{7}$
$\frac{1}{4}$	$\frac{1}{5}$	$\frac{1}{6}$	$\frac{1}{7}$	$\frac{5}{6}$	$\frac{5}{7}$	$\frac{5}{6}$	$\frac{5}{7}$
$\frac{1}{8}$	$\frac{1}{9}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{4}{5}$	$\frac{4}{9}$	$\frac{1}{4}$	$\frac{1}{12}$
$\frac{1}{6}$	$\frac{1}{9}$	$\frac{1}{7}$	$\frac{1}{9}$	$\frac{3}{5}$	$\frac{3}{7}$	$\frac{1}{7}$	$\frac{1}{11}$
$\frac{1}{4}$	$\frac{1}{7}$	$\frac{1}{4}$	$\frac{1}{5}$	$\frac{5}{7}$	$\frac{5}{8}$	$\frac{1}{8}$	$\frac{1}{9}$
$\frac{1}{5}$	$\frac{1}{11}$	$\frac{1}{9}$	$\frac{1}{10}$	$\frac{2}{5}$	$\frac{2}{7}$	$\frac{1}{4}$	$\frac{1}{12}$
—	—	—	—	—	—	—	—

WRITTEN PROBLEMS

If it becomes necessary to add several large fractions, with numerators and denominators of two orders, the following form for the computation will assist in abbreviating the work: Add $2\frac{3}{8}$, $15\frac{5}{12}$, $5\frac{7}{15}$, and $21\frac{11}{24}$.

$2^3 \times 3 \times 5 = 120$

$2\frac{3}{8}$	45
$15\frac{5}{12}$	50
$5\frac{7}{15}$	56
$21\frac{11}{24}$	55
$44\frac{43}{60}$	206
	120
	86

The new denominator is set over the new numerators to be out of the way for the addition of the numerators; the factors of the new denominator, 2^3, 3, and 5, are recorded to assist in the division of the new denominator by the denominators of the factions. To divide 120 by 8; by looking at the factors it can be seen mentally that 3×5 is the quotient; to divide 120 by 24, by looking at the factors, it is clear at sight that 5 is the quotient.

The reduction of $\frac{206}{120}$ to simplest terms is accomplished without unnecessary written work. To test whether $\frac{86}{120}$ is in its lowest terms, test whether any factor 2, 3, or 5 is contained in 86; finding 2, reduce the fraction, and express it in the answer.

The above is sufficient recorded work for the solution of the problem.

Solve the following in the given form using no more written work than is necessary.

1. $14\frac{13}{15}$, $21\frac{11}{21}$, $43\frac{23}{35}$.
2. $8\frac{3}{35}$, $26\frac{7}{42}$, $126\frac{23}{30}$.
3. $\frac{5}{11}$, $\frac{7}{22}$, $\frac{13}{33}$, $\frac{29}{44}$.
4. $6\frac{5}{12}$, $4\frac{5}{18}$, $22\frac{9}{14}$
5. $\frac{4}{9}$, $\frac{7}{12}$, $\frac{3}{7}$, $\frac{5}{18}$.
6. $3\frac{5}{6}$, $4\frac{7}{24}$, $7\frac{5}{14}$.

Much greater facility can be acquired by a large use of factors which this form encourages.

A similar form for subtraction of fractions is given.

Subtract $327\frac{7}{15}$ and $223\frac{17}{18}$.

$3^2 \times 5 \times 2 = 90$

$327\frac{7}{15}$	42
	132
$223\frac{17}{18}$	85
$103\frac{47}{90}$	47

The numerator of $\frac{80}{90}$, borrowed, is added to the numerator of $\frac{42}{90}$ and the result expressed just above the numerator of $\frac{85}{90}$ convenient for the subtraction.

Solve in the above form the following:

1. $8\frac{3}{14} - 5\frac{7}{12}$.
2. $16\frac{3}{22} - 7\frac{14}{33}$.
3. $26\frac{5}{24} - 15\frac{1}{36}$.
4. $31\frac{31}{42} - 4\frac{9}{14}$.
5. $17\frac{13}{18} - 4\frac{5}{12}$.
6. $25\frac{7}{25} - 11\frac{29}{75}$.

MULTIPLICATION OF FRACTIONS

$3 \times \frac{4}{5}$ should be read 3 times $\frac{4}{5}$. How much is $3 \times \frac{4}{5}$? $2 \times \frac{3}{4}$? $4 \times \frac{3}{8}$.

Many such examples should be worked by applying Examples I and II (page 17). This should be continued until the pupil is conscious of the meaning of multiplication of a fraction by an integer.

$$6 \times \tfrac{4}{5} = \tfrac{24}{5} = 4\tfrac{4}{5}. \qquad 5 \times \tfrac{7}{10} = \tfrac{7}{2} = 3\tfrac{1}{2}.$$

Solve:

$7 \times \frac{5}{8}$, $3 \times \frac{4}{7}$, $2 \times \frac{5}{8}$, $8 \times \frac{4}{11}$, $16 \times \frac{3}{32}$, $5 \times \frac{7}{15}$, $3 \times \frac{5}{16}$, $14 \times \frac{3}{5}$, $7 \times \frac{3}{4}$, $11 \times \frac{5}{22}$.

NOTE: In problems of this kind it is better to divide the denominator when it can be done without a remainder.

In almost all cases of multiplication of fractions the simplest rule to be employed is the following:

Rule: *Multiply the numerators together for the numerator of the product and the denominators together for the denominator of the product, abbreviating by cancellation, and reduce the answer to its simplest form.*

If there are mixed numbers or integers among the factors, reduce the former to improper fractions and regard the latter as numerators, or as having one for the denominator.

$7\frac{1}{3} \times 9 \times \frac{5}{6}$. Solution: $\frac{\overset{11}{\cancel{22}}}{\cancel{3}} \times \frac{\cancel{9} \times 5}{\cancel{6}} = 55$

$24 \times 9\frac{3}{4} \times \frac{5}{36}$. Solution: $\cancel{24} \times \frac{\overset{13}{\cancel{39}}}{\cancel{4}} \times \frac{5}{\underset{2}{\cancel{36}}} = \frac{65}{2} = 32\frac{1}{2}$

Solve the following:

1. $3 \times \frac{2}{3} \times 5\frac{1}{2} \times \frac{4}{5}$.
2. $5\frac{2}{3} \times \frac{8}{9} \times 3\frac{3}{5} \times \frac{3}{4}$.
3. $28\frac{2}{3} \times 6$.
4. $16\frac{2}{7} \times 5$.
5. $8 \times 14\frac{2}{5}$.
6. $\frac{3}{4} \times \frac{5}{6}$; $\frac{12}{25} \times 5$.
7. $7\frac{1}{3} \times \frac{5}{11} \times 3\frac{1}{2}$.
8. $3\frac{1}{2} \times 8 \times \frac{5}{28}$.
9. $\frac{4}{5} \times \frac{2}{3} \times \frac{5}{8}$.
10. $8\frac{1}{2} \times \frac{4}{15} \times 7\frac{1}{2}$.
11. $24\frac{1}{2} \times 18 \times \frac{3}{14} \times \frac{5}{7}$.
12. $\frac{5}{6} \times \frac{2}{7} \times \frac{3}{10} \times 2\frac{1}{3}$.
13. $8 \times \frac{5}{6} \times \frac{7}{12} \times \frac{4}{5}$.
14. $9\frac{2}{3} \times \frac{4}{5} \times \frac{30}{31}$.
15. $\frac{27}{28} \times 2\frac{1}{3} \times \frac{4}{9}$.

If two mixed numbers are to be multiplied, it is sometimes better to multiply them as mixed numbers.

In this problem each step in the multiplication is expressed.

$$\begin{array}{r} 312\frac{2}{3} \\ 15\frac{1}{2} \\ \hline 156\frac{1}{3} \\ 10 \\ 1560 \\ 312 \\ \hline 4846\frac{1}{3} \end{array}$$

16. $216 \times 3\frac{2}{3}$.
17. $233\frac{1}{2} \times 16\frac{2}{3}$.
18. $1246 \times 123\frac{1}{2}$.
19. $142\frac{1}{2} \times 316\frac{1}{3}$.
20. $824 \times 14\frac{3}{4}$.
21. $48\frac{1}{2} \times 16\frac{2}{3}$.

DIVISION OF FRACTIONS

Divide 18 by $\frac{2}{3}$.

SOLUTION: $18 \div \frac{2}{3} = 18 \times \frac{3}{2} = 27$.

$5\frac{3}{4} \div 2\frac{1}{4}$.

SOLUTION: $\frac{23}{4} \times \frac{4}{9} = \frac{23}{9} = 2\frac{5}{9}$.

The best general rule for division of fractions is the following:

Rule: *Express mixed numbers as improper fractions, think whole numbers as having one for a denominator, invert the divisor and proceed as in multiplication of fractions.*

The pupil should be grounded in the thought, however, that to divide a fraction by an integer he must divide the numerator or multiply the denominator by the integer. (Principles I and II, p. 19.)

It is always wise in problems of this kind to divide the numerator rather than to multiply the denominator when it can be done without a remainder.

Compare this method with the rule and note whether the two methods are the same.

Solve:

1. $18\frac{2}{3} \div \frac{7}{8}$.
2. $\frac{5}{8} \div \frac{5}{7}$.
3. $23\frac{2}{3} \div 14\frac{1}{6}$.
4. $13\frac{3}{5} \div 25\frac{1}{2}$.
5. $4 \div \frac{5}{6}$.
6. $23\frac{2}{3} \div \frac{5}{6}$.
7. $24 \div \frac{2}{3}$.
8. $18\frac{4}{5} \div 4\frac{2}{5}$.
9. $\frac{7}{9} \div 5$.

Division of a mixed number by an integer can sometimes be abbreviated, if the divisor is not large, by proceeding as in short division; as,

Divide $837\frac{3}{4}$ by 7.

SOLUTION: $7)\,837\frac{3}{4}$

$119\frac{19}{28}$

The 4 remainder $= \frac{16}{4}$ which added to $\frac{3}{4} = \frac{19}{4}$. $\frac{19}{4} \div 7 = \frac{19}{28}$.

Divide $147\frac{2}{3}$ by 6; $352\frac{4}{5}$ by 7; 1,422 by $13\frac{1}{2}$.

THE THREE PROBLEMS OF FRACTIONS

A problem that occurs and recurs in various phases is one involving two factors and their product. In its simplest form all three numbers are integers. From it arise three problems; viz: If three numbers are in the relation of two factors and a product, given any two of them to find

the other; as, (1) Given 5 and 6, to find the product. (2) Given the factor 5 and the product 30, to find the other factor. (3) Given 6 and 30, to find the other factor.

When one of the factors is a fraction, the following forms of the respective problems arise:

I. *To find a fractional part of a number; as,*

To find $\frac{3}{4}$ of 24. Solution $\frac{1}{4}$ of 24 = 6, $\frac{3}{4}$ of 24 = 3 × 6 = 18.

The pupil must realize that the numbers given are factors and the product is to be found. (See multiplication of fractions.)

II. *To find what fractional part one number is of another; as,* 9 is what part of 12? This involves the meaning of a fraction; as, 1 = $\frac{1}{12}$ of 12; then 9 = $\frac{9}{12}$, or $\frac{3}{4}$ of 12. Verify by finding $\frac{3}{4}$ of 12.

2 is what part of 5? 2 = $\frac{2}{5}$ of 5.

8 is what part of 17? 9 is what part of 28? 372 is what part of 976?

III. *To find the number of which a given number is a certain fractional part; as,* 12 is $\frac{4}{7}$ of what number? ($\frac{4}{7}$ × ? = 12.)

Since 12 is 4 parts or sevenths of a number, one of the sevenths is $\frac{1}{4}$ of 12 or 3, and the whole number, or 7 sevenths of it, is 7 × 3 or 21. Therefore, 12 is $\frac{4}{7}$ of 21. Verify by finding $\frac{4}{7}$ of 21, or by finding what part 12 is of 21.

II and III are but phases of the problem, given a product and one factor to find the other factor, and hence are problems in division.

It is important to understand these three problems thoroughly and practically to reduce their solution to the automatic; for, in addition to their value in the realm of fractions, the solution of all problems of percentage rests upon one or the other of them.

PROBLEMS

1. I sold $\frac{2}{3}$ of a farm for \$1,260. What is the whole farm worth?

2. How much should I receive for the $\frac{2}{3}$ of my farm at the same price per acre, if the whole is worth \$1,650?

3. How many pounds of nitrogen in 5 tons of a commercial fertilizer testing $\frac{3}{20}$ nitrogen?

4. Two men planted a field of corn and agreed to divide the corn in proportion to the number of days' work done by each. One worked 27 days and the other 36 days. What part of the product should each have? If the yield is 1,264 bushels, how many bushels should each have?

5. In example 4, if one worked $\frac{3}{5}$ as many days as the other, how many bushels should he get?

THE AREA OF A RECTANGLE

Area is a quantity (page 9) which names the unit of measurement and tells how many times the unit is contained in a given surface; as 25 square inches, 87 square rods, 36 acres.

The *unit of area* is a square with a given linear unit for a side; as, a square inch, square rod, etc.

NOTE: The one exception to this definition is the acre, which means 160 square rods, without regard to shape.

In *measuring* a rectangular surface, the problem is to find the number of given units in the rectangle. The fundamental method is to divide the rectangle into units, or to lay off the unit repeatedly upon the rectangle and count the number thus obtained. This counting can be shortened by counting by rows rather than by squares; in short, multiplying the number in a row by the number of rows.

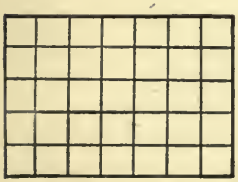

Figure 1.

It can be seen readily that there are as many squares in a row as the number of linear units on one side, and as many rows as there are linear units on an adjacent side. Hence the number of square units in the rectangle equals the product of the number of linear unitsin the length multiplied by the number of linear units in its breadth; or, for short,

Rule: *The area of a rectangle equals the product of its length by its breadth.* (Page 10)

The length and breadth of a rectangle are its dimensions.

The sign $\times$ between dimensions should be read *by*. It has no relation to multiplication. A rectangle $3' \times 8'$ should be read, "a rectangle 3′ by 8′," and means that the rectangle is 3′ wide and 8′ long.

PROBLEMS

In each of the following problems indicate the operation and abbreviate by cancellation. (Page 49, problem XII.)

1. The dimensions of a rectangular field are 80 rods and 160 rods. How many square rods in the field?

2. A field is 40×80 rods. Determine the number of acres. $\frac{40 \times 80}{160} = 20 \therefore = 20$ acres.

3. A room is $12' \times 16'$. How much will it cost to floor it at \$60 per thousand square feet, allowing one quarter extra for matching? Regard a square foot as the unit.

$$\frac{12 \times 16}{1000} \times \tfrac{5}{4} \times 60 = 14\tfrac{2}{5} \therefore = \$14.40.$$

4. If the walls are 8′ high in example 3, what would it cost to plaster the walls and ceiling at 25 cents a square yard, no allowance for doors and windows?

5. A farm is $\frac{1}{2}$ mile $\times$ 1 mile. How many acres? What is the meaning of a "forty"*? Usually what is its shape and what are its dimensions?

6. A farm is 40 $\times$ 160 rods. How many acres? If 60 $\times$ 160 rods? If 160 $\times$ 160 rods?

7. A ball park is 24 $\times$ 24 rods. What will the boards cost for a tight fence 8′ high around it at $30 per 1,000 feet?

8. A fair ground is 80 $\times$ 120 rods. Find cost of boards for fencing with conditions of problem 7.

9. A street to be paved is one mile long and 40′ wide. What does it cost to grade and pave it at $3.20 a square yard?

RECTANGULAR SURVEY

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Figure 2.

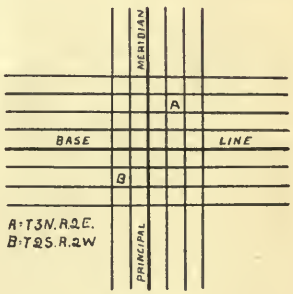

Figure 3.

In the older eastern states the farms are usually irregular in shape, and the lines are indicated by metes and bounds. In the western states a new and simpler system was adopted in 1785. The country is laid out into districts, usually a state, and this is divided into strips running north

*A square containing 40 acres.

and south, six miles wide, called ranges (R), which are numbered east and west from some designated line called the principal meridian. These ranges are divided into squares, called townships, six miles on a side, by east and west lines. These townships (T) are numbered north and south from a designated line called the base line. A township is described, then, for example, T 108 N., R 17 W., state of Minn. The townships are divided into sections one mile square, which are numbered consecutively beginning in the northeast corner and counting as indicated in the diagram. A section is known by its number. A section with a given number always occupies the same relative position in a township.

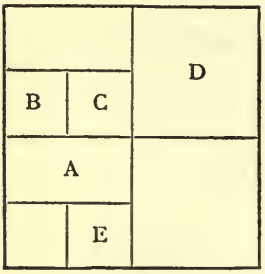

Figure 4. A Section.

The sections are divided, down to ten acres, by bisecting the division lines and drawing lines parallel to the adjacent sides.

Division *D* is described as the N E $\frac{1}{4}$ of Sec 17, T 5 N., R 7 W. B is the S W $\frac{1}{4}$ of N W $\frac{1}{4}$ of Sec. 17, etc.; *A*, N $\frac{1}{2}$ of S W $\frac{1}{4}$ of Sec. 17, etc. Describe *C* and *E*.

PROBLEMS

1. How many acres in *E*? In *D*? In *A*?

2. The N W $\frac{1}{4}$ of S E $\frac{1}{4}$ of a section is worth how much at $70 per acre?

3. The N $\frac{1}{2}$ of S E $\frac{1}{4}$ of N E $\frac{1}{4}$ is worth how much at $90 per acre? Make a drawing to illustrate.

4. What would it cost to fence in the last named piece of land if posts at 20 cents are set a rod apart, the wire three strands high costs $3.50 a hundred rods single strand, and the labor costs $30. What is the cost of the fence per rod?

5. How many acres in a piece of land consisting of the S $\frac{1}{2}$ of the N W $\frac{1}{4}$ and the N $\frac{1}{2}$ of S W $\frac{1}{4}$ of a section? How many rods of fencing to surround it? How many miles?

6. How many rods of fencing are required to surround the N $\frac{1}{2}$ of the N E $\frac{1}{4}$ and the N $\frac{1}{2}$ of the N W $\frac{1}{4}$ of a section? How many acres are enclosed? How could you arrange the same amount of land so as to require the least amount of fencing? How many rods would be saved?

VOLUMES OF RECTANGULAR SOLIDS

Volume is a quantity (page 9) that names the unit of measurement and tells how many times the unit is contained in a given solid; as, 16 cu. in., 37 cu. yds.

The *unit of a solid* is a cube having a given linear unit on an edge; as, a cubic inch, a cubic yard, etc.

In measuring a given solid, the problem is to find the number of times it contains a given cubic unit. (Page 10) The best way to develop a rule is to imagine the solid filled with the cubic units and count them. This requires the laying of a row along an edge, then the number of rows in a layer on the bottom, then layer upon layer until full. Hence it must be determined how many cubes there are in a row along an edge, then how many rows in the bottom or base, then how many layers. As the edge of the unit and the linear unit of the edge of the solid are the same, the number of linear units in the edge of the base is the same as the number of cubic units in a row, the number of linear units in another edge of the base is the same as the number of rows in the base, and the number of linear units in the height of the solid is the same as the number of layers in the solid. Therefore the number of cubes in a layer is the product of the number in a row by the number of rows; and the number

of cubes in the solid is the number of cubes in a layer multiplied by the number of layers.

Given a rectangular solid $5 \times 7 \times 8$. Find its volume.

SOLUTION: Along the edge AB a row of 8 cubic units can be laid, for the edge of the unit is 1 unit long and AB is 8 units long. The layer AC will contain 7 rows, for the row is 1 unit wide and BC the edge of the layer is 7 units long. The solid will contain 5 layers, for the layer is 1 unit high and the edge BE is 5 units long. Hence the layer contains 7×8 or 56 cubic units and the solid contains 5×56, or 280 cubic units, i. e., $5 \times 7 \times 8$ cubic units. Hence the rule:

Let the pupil make a drawing from this description, or build a rectangular solid with inch cubes and verify.

Rule: *Multiply together the number of linear units in each of the three dimensions and give the product the name of the required cubic unit.* Or, as it is commonly expressed, *Multiply together the three dimensions.*

The length, breadth, and thickness of a rectangular solid are its *dimensions.* Sometimes the product of two of them is called the base, and the dimensions are then termed the *base* and *altitude.*

The dimensions of a solid 7′ long, 4′ wide, and 3′ high are usually expressed as $7' \times 4' \times 3'$ and read 7′ by 4′ by 3′.

PROBLEMS

1. The dimensions of a grain bin are 6′, 8′ and 10′. Find its volume in cubic feet.

2. How many bushels in the bin in example 1?*

3. I. H. Sears built a vat $1\frac{2}{3}' \times 2\frac{1}{2}' \times 6'$ in which to make a spraying solution; allowing 2″ of the depth ($1\frac{2}{3}'$) to prevent the solution from boiling over, how many gallons does the vat hold?* How many barrels?

*A foot $= \frac{8}{10}$ or $\frac{4}{5}$ bu. $6 \times 8 \times 10 \times \frac{4}{5} = 384$.

For approximate number of bushels in bins when dimensions are given in feet use $1\frac{1}{4}' = 1$ bu.; for exact number use 2,150.4. The following, also are convenient approximations: $7\frac{1}{2}$ gals. = 1 cu. ft. and $4\frac{1}{2}$ ft. = 1 bbl. (Indicate the operation and abbreviate by cancellation.)

4. A cellar is $18' \times 12' \times 7'$. The owner desires to lay the bottom in cement or grout 4″ deep and the side walls 6″ thick. How many cubic feet of grout are required? If the grout is mixed in the relation 1 part cement, 3 parts sand, and 5 parts gravel, how many bags of cement and cubic yards of gravel are required?*

5. I wish to make a cement watering trough $2\frac{1}{2}' \times 6' \times 8'$, sides 8″ thick and bottom 4″. How much cement, sand, and gravel are required, approximately, if mixed in the proportions 1, 3, and 5? Use outside measurements.

6. How many barrels will the trough hold with the above as inside measurements?

7. If, in 5, the measurements are from the outside, except the depth, how many gallons will the trough hold?

8. How many cords of wood in a pile 4 ft. high, 8 ft. wide, and 80 ft. long? Work mentally, regarding a cord as a pile $4' \times 4' \times 8'$.

9. Find the value of a pile of wood $56' \times 12' \times 6'$ at $6 per cord. Work mentally, using cancellation.

10. A pile of wood is 4 ft. high, 4 ft. wide, 18 ft. long at the top and 22 ft. long at the bottom. What is its real length and how many cords in the pile?

11. A flat roof is $26' \times 36'$; how many inches of rain would have to fall upon it in order to fill a cistern $13' \times 9' \times 12'$?

12. If one and one half inches of rain should fall on the roof in 11, what part of the cistern could be filled from it?

13. Regarding 12 ft. as the depth of the cistern, how deep would $\frac{3}{4}$ of an inch of rain fill it?

14. How many cubic feet of ice 16 in. thick can be cut from an acre ice field, allowing $\frac{1}{10}$ for waste?

*Approximately, 1 bag of cement = 1 cu. ft.

15. How deep would the ice in example 14 fill an ice house 80′ × 66′, inside dimensions?

16. Allowing that the waste of ice in harvesting would be offset by waste of space in packing, how large an ice field expressed in acres would be required to fill an ice house 33′ × 66′ × 80′ if the ice is 16 in. thick?

17. My coal bin is 4′ × 10′ × 10′. How many tons will it hold, assuming that a cubic foot of anthracite coal weighs 55 lbs. and bituminous coal 50 lbs.? Solve for each kind of coal.

18. Measure the dimensions of your bin of coal after leveling the top. Weigh a bushel and determine whether your dealer gave you what he charged for.

19. My wagon box is 3 ft. wide and 10 ft. long. How deep shall I fill it to contain a cubic yard of sand? *

20. My team can readily draw 2 tons over a given road. How deep shall I fill my box with sand to contain a load?*

21. How much does a cubic yard of sand weigh?

DECIMALS

Decimals are like integers in form and meaning, the only difference being, that the units expressed are tenths, hundredths, etc., instead of ones, tens, hundreds, etc. In the number .8273 the unit of 8 is a tenth, of 2 a hundredth, of 7 a thousandth, and of 3 a ten-thousandth; while in 8,273 the unit of 8 is a thousand, of 2 a hundred, of 7 a ten, and of 3 a one.

The plan of reading is the same; viz, read the number as if it were an integer and give it the name of the unit of right-hand figure. .8273 is read eight thousand two hundred seventy-three *ten-thousandths;* while 8,273 is read eight thousand two hundred seventy-three *ones.*

*Sand weighs nearly 1½ times as much as water. 62½ lbs. is the weight of a cubic foot of water.

In the latter case the "ones" is usually omitted, as it is understood, for the unit is always the same, while in decimals the unit of the right-hand figure is variable. Hence facility in reading decimals requires that the names of the orders be memorized, by noting their number from the decimal point; viz., the first, *tenths*; the second, *hundredths*; the third, *thousandths*; the fourth, *ten-thousandths*, etc. It is rare that any order need be considered above the third or fourth, and in an answer above the second.

The units at the right of the decimal point are dealt with in the processes just the same as those at the left, for they are organized on the same decimal system. As the names of the various units or orders are known by their distance from the decimal point, great care should be exercised to keep the decimal point in its proper place, and the rules governing the location of the point should be carefully learned.

In *addition*, as the name of the unit of the sum is the same as the name of the unit added, the point of the sum should be expressed under the point of the addends.

In *subtraction* a corresponding rule applies.

NOTE: As addition and subtraction of decimals are exactly the same as addition and subtraction of simple numbers, and the rule for the point is so simple, this subject can be taken up with the work of addition and subtraction of simple numbers and completed in less time than if treated separately.

MULTIPLICATION OF DECIMALS

In multiplication, to understand the rule for the point, express the multiplier and multiplicand in the form of common fractions, and multiply. It can readily be seen that the point should be located so as to give the product as many places as the sum of those in the multiplier and multiplicand.

$$2.37 \times 4.3 = \frac{237}{100} \times \frac{43}{10} = \frac{10191}{1000} = 10.191$$

Rule: *Multiply as in simple numbers and point off as many places in the product as there are decimal places in both multiplier and multiplicand.*

As the numbers in the respective orders mean the same as in integers; i. e., they tell how many units there are, the one new thing to learn is how to determine the unit of the answer, or, in other words, how to locate the point. This process should be thoroughly memorized and carefully applied.

The check for the answer is the same as in multiplication of simple numbers. (Page 16.)

Solve the following and check the results:

1. $18.73 \times .043$	4. $353.86 \times .24$	7. 36.8×34.7
2. 5.43×3.24	5. $.0236 \times 48.96$	8. $368 \times .347$
3. $1.893 \times .18$	6. 36.8×3.47	9. $.07 \times .007$

10. Barbed wire costs \$.03 a pound and runs a pound to a rod. How much does it cost to supply the wire for a fence 5 strands high and 75.23 rods long? Retain only two decimal places in your answer.

11. If four-inch drain tile costs \$.04 a foot, how much would the tile cost for a ditch 23.6 rods long?

12. A field is 23.5 rods long by 18.3 rods wide. How many square rods in the field?

DIVISION OF DECIMALS

To understand the rule for the point in division of decimals, consider the problem in its relation to multiplication. For instance, divide 10.191 by 2.37.

SOLUTION: 10.191 is the product of 2.37 by the required quotient. Hence, by the rule of multiplication, there must be as many decimal places in the divisor and quotient as in the dividend. So after performing the division as in simple numbers, one place should be marked off in the quotient, as, 4.3.

Rule: *Point off as many places in the quotient as are necessary to make the number of decimal places in the divisor and quotient equal to the number in the dividend.*

To apply the rule, ciphers should be annexed to the dividend to give it as many places as the divisor, if it has fewer.

Probably the method for division of decimals least likely to result in error is the following:

Divide 8912.4 by .024.

SOLUTION: Move the decimal point to the right in the divisor so as to make the divisor a whole number; move the decimal point in the dividend the same number of places to the right, annexing ciphers if necessary; place the decimal point in the quotient directly over the point in the dividend in long division and directly under it in short division. Show that this method accords with the other rule for division of decimals.

The principle involved in moving the point in divisor and dividend is: multiplying both divisor and dividend by the same number does not change the value of the quotient.

```
                371350
              ---------
024)8912400
     72
     ---
     171
     168
     ---
      32
      24
      ---
       84
       72
       ---
       120
       120
       ---
```

The check for division of decimals is the same as for division of simple numbers. (Page 16.)

Solve the following and check the results:

1. 89,036 ÷ 4.7
2. 324.6 ÷ 36
3. 3.964 ÷ 8.44
4. 369.42 ÷ .86
5. 3.6942 ÷ 8.6
6. 36.942 ÷ 86

7. Find the number of acres in a field in example 11, page 40.

8. If a grain bin is 8.4 ft. by 6.5 ft. by 4.2 ft., how many bushels does it hold? Work example 2, page 36, using .8 instead of $\frac{4}{5}$.

9. If an apple barrel holds 2.5 bu., how many barrels are required to hold 356 bu. of apples?

10. A bunch of choice steers weigh, respectively, 1,847, 1,472, 1,563, 1,606, 1,656, 1,476, 1,396, 1,410, and 1,673 lbs.; what are they worth at $8.37? Look up the present quotations and find their value.

11. A wagon box is 10.5 ft. long, 3 ft. wide, and holds 63 bu. by measure. How deep is it? Suppose it holds 95 bu.? Express the answer correct to one decimal place.*

SOLUTION OF INDICATED EXPRESSIONS

A term in arithmetic, as in algebra, is part of an expression set off from the rest of the expression by the plus or minus sign. $3 \times 4 - 2 + 6 \div 4$ is an expression of three terms: 3×4, 2, and $6 \div 4$.

In the solution of such indicated expressions, proceed from left to right, solving the indicated operation *in* the terms before the operation *between* the terms.

1. $3 \times 4 + 2 + 6 \div 4 = 15\frac{1}{2}$
2. $10 - 2 \times \frac{1}{2} - 3 \times 2 \div 4 = 7\frac{1}{2}$
3. $4 \times (8 - 3) + 7 = 27$
4. $\frac{2}{3} + \frac{3}{4} \times \frac{2}{9} - \frac{3}{5} \div \frac{3}{4} = \frac{2}{3} + \frac{1}{6} - \frac{4}{5} = \frac{1}{30}$

Solve the following indicated expressions:

1. $6 + 8 \times 3 - 15$
2. $5\frac{1}{2} - 2.3 + \frac{3}{4} + 8 - \frac{1}{5} \div \frac{4}{5}$
3. $\dfrac{8 \times \frac{3}{4} - 2}{9 - 3 \times 2}$

METHODS OF ABBREVIATION OF VARIOUS OPERATIONS

In the following classes of abbreviated methods many additional examples should be given and frequently be reviewed until the pupil naturally uses the method suggested.

I. *To multiply by 10, 100, 1,000, etc.*

Multiply 866 by 100, and 472 by 10,000.

SOLUTION: $100 \times 866 = 86{,}600$. $10{,}000 \times 472 = 4{,}720{,}000$.

*If the hundreths order is larger than five, increase the tenths by one, if not, drop it.

Rule: *To multiply any number by* 1 *with ciphers annexed, annex as many ciphers to the number as are annexed to the* 1.

Note: 3×4 may be read 3 multiplied by 4 or 3 times 4. The former is the original usage, but the latter to-day generally is regarded the better form.

II. *To multiply a number by any number with ciphers annexed.*

Multiply 342 by 600, and 73 by 12,000.

SOLUTION: $600 \times 342 = 205{,}200$. $12{,}000 \times 73 = 876{,}000$.

Rule: *To multiply a number by any number with ciphers annexed, multiply the given number by the significant figures of the multiplier and annex to the result the number of ciphers annexed to the multiplier.*

If in I or II the multiplicand has decimal orders, move the decimal point to the right instead of annexing ciphers.

Multiply 3.24 by 10, and 2.34 by 300.

SOLUTION: $10 \times 3.24 = 32.4$ $300 \times 2.34 = 702$.

III. *To divide by any number with ciphers annexed.*

Divide 837 by 100, and 837 by 30.

SOLUTION: $837 \div 100 = 8.37$. $837 \div 30 = 27.9$.

Rule: *To divide by any number with ciphers annexed, place a decimal point as many places to the left as there are ciphers annexed to the divisor and divide by the significant figures of the divisor.*

1. $83.24 \div 3{,}200$.
2. $9{,}637 \div 500$.
3. $692.7 \div 5{,}600$.
4. $89.6 \div 24{,}000$.

IV. *To multiply any number by aliquot parts of 100.*

Multiply 8,361 by $33\frac{1}{3}$.

SOLUTION: Since $33\frac{1}{3} = \frac{100}{3}$, annex two ciphers and divide by 3.

$$3)836100$$
$$278700$$

Rule: *Annex two ciphers and divide by the number which represents the aliquot part of 100.*

1. Multiply the following numbers by $33\frac{1}{3}$, also by $.33\frac{1}{3}$ and by $3.3\frac{1}{3}$: 7,932, 6,329, 83.46, 756.1, 437.61, 325, 46.5, 82, 743.

2. Multiply each of the above numbers, correct to two decimal places, by $14\frac{2}{7}$, $16\frac{2}{3}$, $8\frac{1}{3}$, $12\frac{1}{2}$, and 25.

If the multiplicand has decimal orders, move the decimal point the required number of places to the right instead of annexing ciphers; as, $83.426 \times 14\frac{2}{7}$.

SOLUTION: $7)8342.6$
1191.8 $\qquad 14\frac{2}{7} = \frac{100}{7}$

3. Multiply 834 by $3\frac{1}{3}$.

4. Multiply 729.6 by 20 in two ways. Which is the better?

V. *To multiply any number by the multiple of an aliquot part of 100.*

Multiply 8,352 by $66\frac{2}{3}$.

SOLUTION: Since $66\frac{2}{3} = \frac{200}{3}$, annex two ciphers, multiply by 2, and divide by 3.

$$\begin{array}{r} 835200 \\ \times\ 2 \\ \hline 3)1670400 \\ \hline 556800 \end{array}$$

Rule: *Annex two ciphers, multiply the given number by the number which represents the multiple and divide by the number which represents the aliquot part.*

1. Multiply the following numbers by $66\frac{2}{3}$, $6.6\frac{2}{3}$, and $.66\frac{2}{3}$: 487, 38.6, 5.923, 843, 76.29.

Make a rule for multiplying by 75, $37\frac{1}{2}$, $83\frac{1}{3}$, $62\frac{1}{2}$, $87\frac{1}{2}$, $28\frac{4}{7}$, 25, $42\frac{6}{7}$, and $11\frac{1}{9}$.

Multiply the numbers in V (1) by each of them.

VI. *To divide any number by aliquot parts of 100.*

Divide 837 by $33\frac{1}{3}$.

SOLUTION: Since $33\frac{1}{3} = \frac{100}{3}$, $837 \div 33\frac{1}{3} = 8.37 \times 3 = 25.11$.

Rule: *Divide by 100 and multiply by the number which represents the aliquot part of 100.*

1. Divide the following numbers by $33\frac{1}{3}$, $3.3\frac{1}{3}$, and by $.33\frac{1}{3}$: 829, 634.2, 79.54, 6,943, 625.69, 837, 9,625, 47.81.

Make a rule for dividing by the following aliquot parts of 100 and divide each of the above numbers by them: $12\frac{1}{2}$, $8\frac{1}{3}$, $16\frac{2}{3}$, $14\frac{2}{7}$, $9\frac{1}{11}$, $11\frac{1}{9}$.

2. Divide 836.4 by $66\frac{2}{3}$.
Explain the solution at the right.

$$\begin{array}{r} 8.364 \\ \underline{\quad\quad 3} \\ 2)25.092 \\ \hline 12.546 \end{array}$$

Divide the numbers in VI (1) by the following numbers and express the answers correct to two decimal places:

$37\frac{1}{2}$, $83\frac{1}{3}$, $28\frac{4}{7}$, $42\frac{6}{7}$, $57\frac{1}{7}$, $83\frac{1}{3}$, $87\frac{1}{2}$.

VII. *To multiply mixed numbers having identical fractions.*

Multiply $8\frac{1}{2}$ by $12\frac{1}{2}$.

In the solution the process of finding $\frac{1}{2}$ of 8 and $\frac{1}{2}$ of 12 can be abbreviated by taking $\frac{1}{2}$ of 8 + 12, or 20, when the answer can be written with other recorded work.

Multiply:

$$\begin{array}{r} 24\frac{1}{3} \\ \underline{9\frac{1}{3}} \\ 227\frac{1}{9} \end{array}$$

SOLUTION:

$\frac{1}{3} \times 33 = 11$

$9 \times 24 + 11 = 227$

$$\begin{array}{rrrrr} 16\frac{1}{5} & 28\frac{2}{3} & 18\frac{1}{3} & 63\frac{1}{4} & 82\frac{1}{2} \\ \underline{4\frac{1}{5}} & \underline{9\frac{2}{3}} & \underline{12\frac{1}{3}} & \underline{7\frac{1}{4}} & \underline{8\frac{1}{2}} \\ 68\frac{1}{25} & 277\frac{1}{9} & & & \end{array}$$

Rule: *Multiply the fractions and set down the product. Multiply the sum of the whole numbers by the identical fraction and add the product to the product of the whole numbers.*

VIII. *To multiply numbers of two orders having identical units or tens.*

$$\begin{array}{r} 83 \\ \underline{63} \\ 5229 \end{array}$$

SOLUTION: $3 \times 3 = 9$. 3×14 ($3 \times \overline{6 + 8}$) $= 42$.
Express the 2. $6 \times 8 = 48$.
$48 + 4 = 52$.
It can be seen that 3×3 added to 3×6 is the same as 3×9.

Rule: *Multiply the units by the units, express the units and carry the tens. Multiply the sum of the unlike numbers in any order by one of the identical numbers in the other order, set down the right-hand figure and carry the left; multiply the tens by the tens and set down the product.*

Record only the answers of the following:

27×57 42×62 18×58 82×42

24
23
552

SOLUTION: $3 \times 4 = 12$.
Express the 2. $2 \times 7\ (2 \times 3 + 4) = 14$.
$14 + 1 = 15$.
Express the 5. $2 \times 2 + 1 = 5$.

23×25 46×44 92×93 36×34

In the following, in the usual way, perform the process mentally and record only the answer; as,

62
25
1,550

82×26 63×27 18×24
16×23 43×55 28×53
28×43 56×42 84×33

IX. *To square a mixed number whose fraction is one half.*

Multiply $3\frac{1}{2} \times 3\frac{1}{2}$, or square $3\frac{1}{2}$.

SOLUTION: $3\frac{1}{2}$
$3\frac{1}{2}$
$12\frac{1}{4}$

$\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$. $\frac{1}{2}$ of $3 + \frac{1}{2}$ of 3 or $1 \times 3 = 3$.
$1 \times 3 + 3 \times 3 = 4 \times 3 = 12$.
$12 + \frac{1}{4} = 12\frac{1}{4}$; or $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$.
$3 \times 4 = 12$ $\therefore 3\frac{1}{2} \times 3\frac{1}{2} = 12\frac{1}{4}$.

Rule: *To square a mixed number in which the fraction is one half, square the fraction, add one to one of the integers and multiply the result by the other integer.*

$5\frac{1}{2}$
$5\frac{1}{2}$
$30\frac{1}{4}$

SOLUTION: $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$. $5 \times 6 = 30$.
In multiplying, $\frac{1}{2} \times 5 + \frac{1}{2} \times 5 = 1 \times 5$. $(1 + 5) \times 5 = 6 \times 5$.

Solve the following:

$8\frac{1}{2} \times 8\frac{1}{2}$ $6\frac{1}{2} \times 6\frac{1}{2}$ $20\frac{1}{2} \times 20\frac{1}{2}$
$4\frac{1}{2} \times 4\frac{1}{2}$ $9\frac{1}{2} \times 9\frac{1}{2}$ $12\frac{1}{2} \times 12\frac{1}{2}$
$7\frac{1}{2} \times 7\frac{1}{2}$

X. *To multiply sets of factors.*

From the fact that $2 \times 5 = 10$, where 2's and 5's are found in sets of factors the multiplication can be abbreviated by setting aside the pairs of 2's and 5's, multiplying the remaining factors together, and annexing as many ciphers as there are pairs of 2's and 5's; as, $25 \times 16 \times 75 = (2 \times 5) \times (2 \times 5) \times (2 \times 5) \times (2 \times 5) \times 3 = 30{,}000$.

With a knowledge of factoring it is easily seen that there are four pairs of 2 and 5 and one 3; hence the answer is 3 with four ciphers annexed.

Multiply 24 by 15 by 5. *Ans.* 1,800.

By this method solve the following mentally:

1. $8 \times 15 \times 75$. 3. $8 \times 75 \times 15 \times 4$. 5. 42×15.
2. $24 \times 25 \times 15$. 4. $56 \times 75 \times 15$. 6. 828×75.

To multiply such a group as 8, 9 and 24. It is shorter to multiply in the order 24, 8, and 9 than 8, 9, and 24. Multiply 24 by 8 or 9 simply setting down the answer, then the result by the other factor. But to multiply 24 by 72 takes longer. Try it.

Multiply:
1. 8, 3, 24 and 5
2. 734, 6 and 10
3. 46, 9, 12 and 3
4. 20, 6 and 18
5. 62, 4, 8 and 12
6. 7, 12 and 13

XI. *Abbreviation by Cancellation.*

It has been shown that, if the numerator and denominator of a fraction are divided by the same number, the value of the fraction is not changed. (Prin. III, page 21.) It can be shown in the same way that, if the divisor and dividend are both divided by the same number, the quotient remains the same.

Show by experiment that this is true.

If the product of several factors is to be divided by the product of other factors, the division can be abbreviated by striking out common factors from both dividend and divisor.

Divide $27 \times 8 \times 16 \times 42$ by $24 \times 28 \times 12$

SOLUTION:
$$\frac{\overset{9}{\cancel{27}} \times \overset{4}{\cancel{8}} \times \overset{2}{\cancel{16}} \times \overset{6}{\cancel{42}}}{\underset{8}{\cancel{24}} \times \underset{7}{\cancel{28}} \times \underset{3}{\cancel{12}}} = 18$$

Divide $26 \times 36 \times 72$ by $56 \times 7 \times 18$

SOLUTION:
$$\frac{\overset{13}{\cancel{26}} \times 36 \times \overset{9}{\cancel{72}}}{\underset{7}{\cancel{56}} \times 7 \times \underset{9}{\cancel{18}}} = \frac{13 \times 36}{7 \times 7} = \frac{468}{49} = 9\tfrac{27}{49}$$

The problem, after cancellation, simply requires that 36 be multiplied by 13 and divided by 7×7, which requires much less computation than to perform the operations originally indicated.

Such problems as the following can be solved mentally.
$36 \times 42 \div 63 = 24$

Write the answers at sight of the following:

1. $84 \times 63 \div 108$
2. $36 \times 34 \div 72$
3. $24 \times 18 \div 72$
4. $57 \times 85 \div 95$
5. $57 \times 85 \div 51$
6. $49 \times 24 \div 56$
7. $52 \times 18 \div 9 \times 13$
8. $72 \times 15 \div 40$
9. $35 \times 75 \times 6 \div 5 \times 15 \times 30$
10. $45 \times 75 \div 125$

In performing the operation of cancellation it is usually more convenient to place the dividend over the divisor. (Page 15.) When one has a quotient factor either above or below the line, it does not pay to set it down if it can be immediately canceled. There is sufficient written work in the following examples. A different order of cancellation, of course, would give a different solution, but the same answer.

Care must be exercised to set down a factor that cannot be canceled, to avoid error in result.

$$\frac{\overset{2}{13}\times\overset{3}{78}\times\overset{2}{24}\times\overset{2}{14}}{\underset{7}{91}\times\underset{7}{38}\times\underset{}{56}} = 1\tfrac{5}{7}$$

$$\frac{\overset{2}{18}\times\overset{2}{26}\times\overset{}{35}\times\overset{}{24}}{\underset{}{72}\times\underset{3}{63}\times\underset{}{63}} = 1\tfrac{1}{3}$$

$$\frac{\overset{7}{13}\times\overset{4}{26}\times\overset{}{35}\times\overset{}{24}}{\underset{}{52}\times\underset{3}{65}\times\underset{}{63}} = 1\tfrac{1}{3}$$

Solve the following:

1. $57 \times 91 \times 85 \times 42 \div 34 \times 95 \times 52$
2. $56 \times 24 \times 85 \times 32 \div 84 \times 16 \times 15$
3. $27 \times 72 \times 63 \times 20 \div 54 \times 56 \times 76$
4. $91 \times 87 \times 76 \times 24 \div 58 \times 29 \times 56$

XII. *Straight Line Analysis.*

In the solution of many concrete problems in more or less numerous operations of multiplication and division, much time can be saved by indicating the operations with the multipliers above the line, the divisors below the line and abbreviating the computations by cancellation. If fractions occur as multipliers, put numerators above the line and denominators below. If a fraction occurs as a divisor, invert the fraction and proceed as above. Page 30.

1. Find the capacity in barrels of a cement watering trough $1\frac{1}{2}' \times 7' \times 11'$ inside measurement.

SOLUTION:

$$\frac{3 \times 7 \times 11 \times 12^3 \times 2}{2 \times 231 \times 63} = \frac{192}{7} = 27.4$$

SUGGESTIONS: $\frac{12 \times 12 \times 12}{231}\left(\frac{12^3}{231}\right)$ = number of gallons in a cubic foot.

$31\frac{1}{2} = \frac{63}{2}$ = number of gallons in a barrel. To divide by this fraction, invert and multiply. $\frac{12^3}{231} = 4\frac{1}{2}$ nearly.

A close enough approximation can be obtained by using $4\frac{1}{5}$ cu. ft. = 1 bbl.

SOLUTION: $$\frac{3 \times 7 \times 11 \times 5}{2 \times 21} = \frac{55}{2} = 27.5$$

2. Find the number of tons in a rectangular block of granite 6′ × 6′ × 4′, specific gravity 2.6. (Page 241.)

SOLUTION: $$\frac{3 \quad 3 \qquad\qquad 13}{6 \times 6 \times 4 \times 125 \times 26} = 11.7$$
$$2000 \times 2 \times 10$$

3. The state of Massachusetts requires by law that school buildings shall furnish each pupil 30 cu. ft. of fresh air per minute. A school building seating 40 pupils has an exit register $2\frac{1}{2}' \times 2\frac{1}{2}'$. With air moving through the register 5 lineal feet per second, is the ventilation up to the legal requirements, assuming that obstructions in the register reduce the opening $\frac{1}{5}$? If air moves 5 ft. per sec., the volume is $(2\frac{1}{2})^2 \times 5$ cu. ft. per sec.

SOLUTION: $$\frac{5 \times 5 \times 5 \times 4 \times 60}{2 \times 2 \times 5 \times 40 \times 30} = \frac{5}{4} = 1\frac{1}{4}$$

4. If corn is planted 3′ 8″ each way, how many hills are there per acre?

SOLUTION: $$\frac{40}{160} \times \frac{33}{2} \times \frac{33}{2} \times \frac{3}{11} \times \frac{3}{11} = 3240.$$

In reductions involving square and cubic units, it is enough to remember the linear table and use the number involved twice for area and three times for volume. For instance:

12^3 cu. in. = 1 cu. ft.
$16\frac{1}{2} \times 16\frac{1}{2}$ sq. ft. = 1 sq. rd.
4′ × 4′ × 8′ = a cord.

5. How many bushels of corn in a 20-acre field, if planted 3′ 8″ apart each way, averaging 3 stalks to the hill, 4 good ears to 5 stalks, and 120 ears to the bushel?

6. What is the value of 15 acres of such corn at 70 cents per bushel?

7. Work mentally:

(a) A pile of cordwood is $80' \times 6' \times 4'$. How many cords?

(b) What is the value of a pile of wood $40' \times 8' \times 6'$ at \$7 per cord?

(c) Find the value of a pile $96' \times 4' \times 4'$ at \$6 per cord.

8*. If trees are planted 20 ft. apart by the rectangular system, how large a square is devoted to each tree? Make a drawing to illustrate.

9. By the rectangular system, if cherry trees are planted $16\frac{1}{2}$ ft. apart, how many trees in 12 acres?

10. If apple trees are planted by the rectangular system, 22 feet apart, how many trees can be planted to the acre? If planted $18' \times 20'$?

11. At what distance apart would trees be planted by the rectangular system, if 196 plum trees were planted to the acre?

12. How many tons of water in an inch of rainfall on an acre of ground? On 12 acres?

13. What is the value of a piece of land 40×60 rods at \$150 an acre?

MEASUREMENT OF LUMBER

The unit of lumber, primarily, is the board foot, though lumber is bought and sold by the thousand feet.

The *board foot* is a magnitude $1' \times 1' \times 1''$. Twelve board feet make a cubic foot.

Lumber is always sawed at the mills an even number of feet in length; in the main, 12′, 14′, 16′, and 18′ long, though longer and shorter lengths can be obtained, and it is always

*The rectangular system, 20′ apart, means parallel rows each way at right angles to each other 20′ apart.

an integral number of inches wide, usually an even number.

In computing amounts of lumber, anything less than an inch thick is regarded as an inch, though the price of the lumber usually varies according to the thickness.

To find the number of board feet in lumber.

As a board foot is $1' \times 1' \times 1''$, the number of board feet in a given piece of timber is the product of the length and width in feet by the number of inches in thickness.

How many board feet in a board $14' \times 12'' \times 1''$? Think of it as sawed up into boards $1' \times 1' \times 1''$ and note how many there are.

How many board feet in a stick $2'' \times 10'' \times 18'$?

In solving this it becomes necessary by above statement to think the product of $2 \times \frac{10}{12} \times 18$; but as the product of $2 \times \frac{10}{12} \times 18$ is the same as $\frac{2 \times 10 \times 18}{12}$ it is simpler to cancel 12 wherever possible; hence the rule:

Rule: *To find the number of board feet in a piece of lumber, multiply the dimensions as given and divide by twelve, abbreviating by cancellation when possible.*

How many board feet in 20 pieces (pcs.) of lumber $6'' \times 8'' \times 16'$?

Solution: Cancel mentally the factors of 12 in 6 and 8, leaving to be multiplied 20, 4, and 16, which equals 1,280 board feet.

Work mentally the following:

Find amount of lumber in:

1. 12 pcs. $2'' \times 4'' \times 16'$.
2. 8 pcs. $2'' \times 6'' \times 20'$.
3. 18 pcs. $2'' \times 4'' \times 16'$.
4. 24 pcs. $2'' \times 8'' \times 10'$.
5. 13 pcs. $3'' \times 4'' \times 12'$.
6. 16 pcs. $2'' \times 6'' \times 12'$.

Solve mentally or with as little pencil work as is necessary for facility: (Page 48.)

7. 24 pcs. $2'' \times 8'' \times 18'$.
8. 16 pcs. $3'' \times 8'' \times 16'$.
9. 43 pcs. $2'' \times 6'' \times 20'$.
10. 18 pcs. $4'' \times 4'' \times 16'$.

To find the cost of lumber, multiply the number of board feet by the price per thousand and point off three places.

In practice, as one does not wish to have more than two decimal places to express dollars and cents, it is customary to drop the number 10 from among the factors when it occurs and point off two places; as,

20 pcs. $3'' \times 8'' \times 16'$ @ \$25 = 16×100 = \$16. (Page 45., X.)

Compute mentally, applying appropriate abbreviations.

1. 12 pcs. $1'' \times 12'' \times 16'$ @ \$30.
2. 8 pcs. $2'' \times 10'' \times 18'$ @ \$25.
3. 24 pcs. $1'' \times 10'' \times 16'$ @ \$50.
4. 30 pcs. $2'' \times 12'' \times 16'$ @ \$20.
5. 18 pcs. $2'' \times 4'' \times 12'$ @ \$25.
6. 25 pcs. $2'' \times 12'' \times 18'$ @ \$23.

Solve with as little pencil work as possible. Find value of:

7. 16 pcs. $2'' \times 4'' \times 16'$ @ \$24.
8. 36 pcs. $2'' \times 8'' \times 16'$ @ \$27.
9. 40 pcs. $4'' \times 8'' \times 18'$ @ \$21.
10. 33 pcs. $2'' \times 6'' \times 16'$ @ \$30.

SQUARE ROOT

In many problems it is necessary to extract the square root of numbers. By having a table of the square roots of the prime numbers to 19 or higher inclusive, most of the problems can be solved without resorting to the "long rule." (See Appendix, page 249.)

To extract square root is to find one of two equal factors of a number. If a number can be divided into pairs of equal factors, the process is very simple; as $256 = 2^8$; hence 2^4 or the product of half of the 2's is the square root.

$$\sqrt{576} = \sqrt{9} \times \sqrt{2^6} = 24.$$

But in case there is an odd number of factors, the root of the odd factors must be found, or the table be used.

SOLUTION: $72 = 6\sqrt{2}$. $\sqrt{2} = 1.414$. $6 \times \sqrt{2} = 8.484$. $96 = 4\sqrt{6} = 4 \times \sqrt{2} \times \sqrt{3}$. $\sqrt{2} = 1.414$. $\sqrt{3} = 1.73$. $4 \times 1.414 \times 1.73 = \sqrt{96}$.

But without a table of square roots at hand it is necessary to know how to extract the square root of numbers.*

*For pupils under the second year of the high school probably the best method is to commit the rule to memory and work enough examples by it to get a fair degree of facility.

Rule for Square Root

Divide the number into periods of two figures each counting both ways from the decimal point. Subtract the largest second power from the left hand period, and bring down the next period. Double the root figure for a trial divisor and find how many times it is contained in the new partial power, omitting the right hand figure, or regarding the trial divisor as tens. Annex the new root figure to the trial divisor; multiply by the root figure, subtract from the partial power, and bring down the next period. Double the root already found and proceed as before.

```
   621.1
 385824.00
     36
    258
122)244
    1424
1241)1241
    18300
12421)12421
     5879
```

For those who would like to look into the reasons for the rule, an explanation is appended on page 249.

The matter of its use is left to the judgment of the teacher.

1. Extract the square root of 27 in two ways (suggestion: $27 = 3\sqrt{3}$); of 892.534; of 6374.5.

2. Extract the square root of 2, 3, 5, 7, 11, 13, 17 and 19 correct to two decimal places, and compare with the table (page 249). It is well to commit to memory $\sqrt{2}$, $\sqrt{3}$, and $\sqrt{5}$.

3. Extract the square root of 89.7324; of .639; of 2973.642; of 18.

THE RIGHT TRIANGLE PROBLEM

I. *Given two sides of a right triangle to find the hypotenuse.*

Let ABC represent a right triangle, with AC the *hypotenuse*. AB and BC are called *sides* or *legs* of the right triangle.

The *hypotenuse* is the side opposite the right angle.

If $AB = 4$ in., $BC = 3$ in. and the triangle be drawn to a scale and squares be drawn on the three sides, it will be found that the sum of the areas of square AB and square BC will equal the area of square AC; viz, 25. Therefore, side AC is 5.

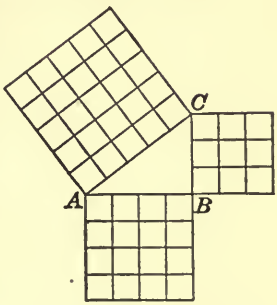

Figure 6.

Draw a right triangle with legs 5 and 12. What is the hypotenuse? Test it by measurement.

This **principle** is established in general in geometry and may be stated: *The square on the hypotenuse equals the sum of the squares on the other two sides of a right triangle.*

I. *Given the two sides of a right triangle to find the hypotenuse.*

Rule: *Extract the square root of the sum of the squares of the two sides.*

II. *Given the hypotenuse and one side to find the third side.*

Rule: *Extract the square root of difference between the square of the hypotenuse and the square of the remaining side.*

PROBLEMS

1. A carpenter wishes to know that the frame of a building he is laying has right angles as it lies upon the foundation. He measures 6 ft. from a corner along one timber, 8 ft. from the corner along the other, and then measures across between the two points located. He then adjusts the frame until the distance across is 10 ft. Is he justified in so doing?

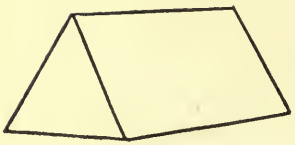

Figure 6.

2. I wish to build a portable $\wedge$-shaped pig cot 6 ft. wide, 8 ft. long, and 6 ft. high; what length of boards shall I need for the slope? How much waste lumber, if I use 14-foot boards in making the roof?

3. If I make the length of slope just 7 ft., how high will the cot be, the width remaining the same?

4. In planning a building it is decided to make the distance between the eaves 30 ft. and that the roof be one third pitch. What is the length of the rafter?

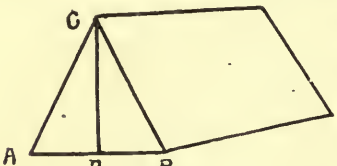

Figure 7.

One third pitch means that the perpendicular distance from ridge to the line between the eaves is one third the latter line. If CD is the perpendicular to AB, the roof would be one third pitch, if CD is one third of AB; one half pitch, if CD is one half AB.

5. I want to use a 16-ft. rafter, and the line between the eaves is 24 ft. What is the pitch of the roof?

6. What is the length of the diagonal of a square 5 ft. on a side? Knowing $\sqrt{2} = 1.41$, solve without extraction of a root.

7. Solve by extracting the root, as a check.

8. Solve examples 4 and 5 by use of the table of roots.

9. How many square feet in the gable end of a house 18 ft. wide, 16 ft. high to the plate, and 25 ft. high to the ridge? (The area of a triangle $= \frac{1}{2}$ base $\times$ altitude.)

10. If the house in example 9 is 24 ft. long, and rectangular, how many square feet must be clapboarded? Take no account of doors and windows.

11. I wish to plant apple trees on the hexagonal system 24 ft. apart in the row; how far is row AB from row CD? How many trees can be planted to the acre? (See page 206.)

A . . . . B
C . . . . . D
E . . . . . F

The distance between rows AB and CD is the perpendicular from one tree to the mid-point of the line between two opposite trees.

AREA OF A TRIANGLE

The *dimensions* of a triangle are its base and altitude.

Any side of the triangle may be taken for the *base.*

The *veriex* of a triangle is the vertex opposite the base.

The *altitude* is the perpendicular distance from the vertex of the triangle to the base.

I. *To find the area of a triangle when the altitude and base are given.*

SOLUTION: Find the area of the triangle ABC. Study the figure and compare parts I and II, III and IV of the rectangle in figure 8. Compare triangle ABC with rectangle BCEF.

The area of the rectangle is BC × AD.

The area of the triangle $= \frac{BC \times AD}{2}$.

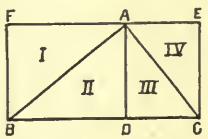

Figure 8.

Rule: *The area of a triangle equals one half of the product of the base by the altitude.*

PROBLEMS

1. The altitude of a triangle is 24 ft., the base 40 ft. What is its area? If the dimensions are 17 and 24, 13 and 18, 17 and 23, find the respective areas.

2. A piece of land in triangular form has a base of 20 rds. and an altitude of 12 rds. How many acres in the area?

3. Drive three stakes for the vertices of a triangle, make the required measurements and find the area inclosed.

II. *To find the area of a triangle, if the three sides are given.*

Rule.: *Multiply one half the sum of the sides by the three factors formed by subtracting the three sides, respectively, from one half of the sum of the sides and extract the square root.*

The sides of a triangle are 12, 13, and 15. Find its area.

SOLUTION: $(13 + 15 + 12) \div 2 = 20$; $20 - 13 = 7$; $20 - 15 = 5$; $20 - 12 = 8$; $20 \times 7 \times 5 \times 8 = 5{,}600$. The $\sqrt{5600} = 74.83+$.

PROBLEMS

1. Find the number of acres in a tract of land in triangular form whose sides are respectively 20, 24, and 30 rds.

2. A swamp triangular in shape has sides 7, 10 and 11 miles respectively. How many acres in the swamp?

THE AREA OF A TRAPEZOID

A *trapezoid* is a figure of four sides having two and only two sides parallel. The parallel sides are the *bases* of the trapezoid and the perpendicular distance between the bases is the *altitude* of the trapezoid.

To find the area of a trapezoid.

SOLUTION: Draw a diagonal of the trapezoid, as AC. ABC and ADC are two triangles having the altitude MN and the bases AB and DC respectively. The area of the trapezoid is:

$$\frac{AB \times MN}{2} + \frac{CD \times MN}{2}$$

or

$$\frac{(AB + CD) \times MN}{2}.$$

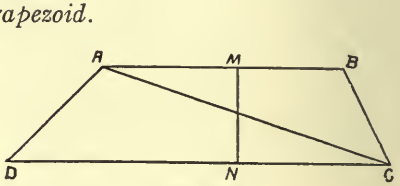

Figure 9.

Rule: *To find the area of a trapezoid multiply the altitude by the sum of the bases and divide by two.*

The bases of a trapezoid are 9 ft. and 12 ft. and the altitude is 8 ft. Find its area.

SOLUTION: $\frac{(9 + 12) \times 8}{2} = \frac{21 \times 8}{2} = 84.$

PROBLEMS

1. A tract of land in the form of a trapezoid has an altitude of 20 rds. and the parallel sides are 40 and 60 rds. respectively. How many acres in the tract?

2 A section of land has a railroad running obliquely across it. The parallel sides of one part are, respectively, 247 rods and 133 rds. How many acres in each piece?

3. A man owned a quarter section of land divided by a highway cutting two opposite sides 40 rds. and 100 rds., respectively, from two adjacent corners. He sold the smaller piece. How many acres did he sell?

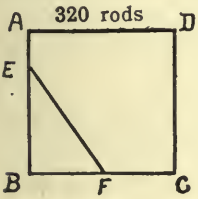

Figure 10.

4. ABCD represents a section of land. AE is 44 rds. and FC is 96 rds. How many acres in each piece? How long is line EF?

5. How many acres in the trapezoid indicated by the figure at the right?

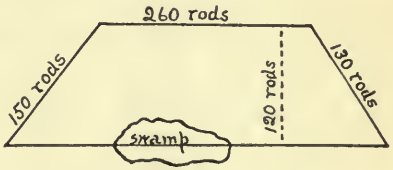

Figure 11.

THE CIRCLE

A *circle** is a portion of a plane bounded by a closed curved line every point of which is equally distant from a point within called the *center*.

A *circumference* (C) is the line which bounds a circle.

The *radius* (R) of a circle is a straight line drawn from the center to the circumference.

The *diameter* (D) of a circle is a straight line through the center and limited by the circumference.

* This definition is the one generally used in arithmetics, but in other mathematics the circle is usually described as a curved line synonymous with circumference.

The *area of a circle* is the area of the surface bounded by the circumference.

I. *To find the ratio of the circumference to the diameter.*

This ratio is called Pi (π).

Measure carefully the distance around a barrel, tin pail, any cylindrical object, and also the diameter of the same. Divide the former measurement by the latter. The quotient will approximate $3\frac{1}{7}$.

Let each member of class make from two to six such measurements and bring the averages to class. Throw out of the average any result that manifestly is in error by being much different from the others. Then average the remaining averages. In this way a fairly close approximation to the true ratio can be obtained.

The purpose of this work is not so much to obtain the true ratio as, by his experience in obtaining it, to have the pupil appreciate its meaning.

The value of π to four decimal places is 3.1416; to five, 3.14159. For all practical purposes for the farmer or mechanic $3\frac{1}{7}$ is sufficiently correct. Expressed in symbols, $C = \pi D$, or $C = 2\pi R$.

1. The diameter of a circle is 14 ft. Find the circumference.

SOLUTION: $\frac{14' \times 22}{7} = 44'$.

2. The diameter of a circle is 6 in. What is the length of the circumference?

3. What is the distance around a $1\frac{1}{2}$-in. strawberry? A $3\frac{1}{2}$-in. apple? A 15-in. pumpkin? A 3-ft. tree? For such approximations let Pi = 3. Obtain the answer without a pencil.

4. If the distance around a tree is 37 ft., what is its diameter? Express the answer in the nearest integer.

5. The circumference of an apple is 9 in. What is its diameter?

6. Find the length of a circle 21 ft. in diameter by using $3\frac{1}{7}$ for π. Then find its length by using 3.1416, and subtract to find the difference. Is the first answer too large or too small?

II. *To find the area of a circle.*

Cut a slice half an inch thick from a potato, turnip, apple, or other round object, and cut it into halves through a diameter. Then cut each piece from the center along the radii, not severing the skin; as,

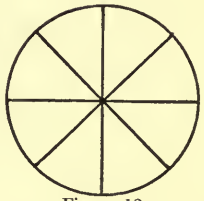

Figure 12

Fit the two pieces together with the skin outward; as,

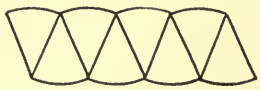

Figure 13.

This form approximates a parallelogram or rectangle, the area of which is the base times the altitude ($B \times A$) (Page 31). Now express the base and altitude in terms of the circle.

Another way to think out the area is to compute the area from the triangles formed. If cut into 10 triangles, each triangle would equal $\frac{1}{2}R \times \frac{1}{10}C$. All the ten triangles would equal $\frac{1}{2}R \times C = \frac{R \times C}{2}$.

III. *To express area in terms of radius:*

SOLUTION: The area of a circle $= \frac{R \times C}{2}$.

Since $C = 2\pi R$, the area $= \frac{R \times 2\pi R}{2} = \pi R^2$.

These formulae, $C = \pi D$, $C = 2\pi R$, area equals $\frac{R \times C}{2}$ and area $= \pi R^2$, should be thoroughly memorized, for it is often convenient to use one or more of them.

1. What is the area of a circle whose radius is 7? Whose radius is 12? Whose diameter is 8? 21? 24?

2. What is the area of the cross-section of a tree 36 in. around? 91 in. around? Measure several trees and find the areas of cross-sections.

3. A sequoia tree is 21 ft. in diameter. What is the area of a cross-section?

4. A horse is tied to a stake in an open field with a tether 4 rds. long. What part of an acre can he graze?

5. One circle has a diameter of 3 in., another a diameter of 6 in. How many times as much area in the second as in the first?

6. If the second circle in example 5 has 3 times the diameter of the first, how does its area compare with the first? If 4 times? If 5 times?

Formulate a statement as to how areas of circles compare in terms of their diameters.

7. Two drains with tiles 3 in. and 4 in. respectively unite. What diameter of tile should be used to carry a full head of water from the two drains.

The principle is the same as in the Right Triangle problem. (Page 54.)

8. If three lines of tile 4, 6, and 8 in. unite, what size of tile should be used in the continuation drain?

VOLUMES OF CYLINDERS

A *cylinder* is a solid bounded by two circular faces and a curved surface. A section of a stove pipe, a baking powder can, etc., illustrate a cylinder. The circular faces are the *bases* of the cylinder.

The *altitude* of a cylinder is the perpendicular distance between the bases.

Cylinder is a much broader term than above defined, but the definition given covers general usage.

The base and altitude of a cylinder are its *dimensions.*

To find the volume of a cylinder, take a root, as a carrot, potato, turnip, from which a fairly good cylinder can be cut, having the skin for the curved surface. Cut it as you did in finding the area of a circle. Place it, as before, in the form of a rectangular solid. Use the cut surfaces for bases. What is its volume? Express the volume in formulae; i. e., in terms of altitude, R, and π.

Rule: *To find the volume of a cylinder, multiply the area of its base by the altitude.* Expressed in a formula, the volume $= \pi \times R^2 \times h$, h being the symbol for altitude, or height.

PROBLEMS

1. A circular watering tank is 7 ft. in diameter and $2\frac{1}{2}$ ft. deep. How many cubic feet of water does it hold? How many gallons? How many barrels ($31\frac{1}{2}$ gal.)?

· For approximations of this kind $4\frac{1}{5}$ cu. ft. or even 4 cu. ft. per barrel is near enough.

SOLUTION:

$$\frac{22}{7} \times \frac{7}{2} \times \frac{7}{2} \times \frac{5}{2} \times \frac{\overset{4}{12} \times \overset{4}{12} \times \overset{4}{12}}{231} \times \frac{2}{\underset{7}{63}} = \frac{160}{7} = 22\tfrac{6}{7}$$

or $$\frac{\overset{11}{22}}{7} \times \frac{7}{2} \times \frac{7}{2} \times \frac{5}{2} \times \frac{5}{\underset{3}{21}} = \frac{275}{12} = 23-$$

What part of a barrel is the difference between the two results? Which is the approximation?

2. A circular cistern is 6 ft. in diameter and 8 ft. deep inside measurements; how many barrels does it hold?

3. A circular silo is 14 ft. in diameter and 30 ft. deep; how many cubic feet of silage does it hold?

4. How many cubic feet in a section of a tree trunk 45 in. around and 28 ft. high? Allowing 4 in. of diameter for slabs and $\frac{1}{4}$ for sawdust, how many board feet approximately? If $\frac{1}{2}$ of the slabs can be utilized for shingles, laths, etc., how many feet of waste? What part of the log is waste? Use 3 for π.

5. A steam boiler is 4 ft. in diameter and 18 ft. in length, and has 24 fire tubes 4 in. in diameter and 18 ft. long running through it. How many gallons does the boiler hold when $\frac{7}{8}$ full?

6. Find the specific gravity of a piece of rock.

SUGGESTION: Immerse the piece of rock in a cylinder partly full of water and carefully measure the amount the water rises in the cylinder. How can its volume be found from this result? See definition of Spec. Gr. (page 241) and complete the problem.

THE CONE*

A *cone* is a solid bounded by a circle and a curved surface from all points of which straight lines can be drawn to a point called the vertex.

The circle is the *base* of the cone.

The perpendicular distance from the vertex to the base is the *altitude* of the cone.

If grain is poured from the same point upon a level surface the shape of the pile will approximate a cone. A cornucopia is cone-shaped.

The *dimensions* of a cone are its base and altitude.

The *volume of a cone* is one third that of a cylinder having the same base and altitude.

To find the volume of a cone.

SOLUTION: Construct a cylinder out of cardboard. It is not necessary to make the base. Set it upon a level surface and fill with sand, corn, or other convenient material. Construct a cone with the

*This subject may be omitted in the discretion of the teacher as its practical value is small.

same base and altitude as the cylinder and see how many times the material in the cylinder will fill the cone. If made accurately, the cylinder will fill the cone three times.

Rule: *To find the volume of a cone multiply the base by one third the altitude.*

1. A cone-shaped pile of wheat has an altitude of 5 ft. and a diameter of 9 ft.; how many bushels, approximately, in the pile? Use 3 for π.

2. What measurements would you make to approximate the number of bushels in a heap of grain piled as high as possible and with a circular base?

3. A circular crib of chicken wire 8 ft. in diameter and 4 ft. high is filled with ear corn to a point 7 ft. from the ground. How many bushels, approximately, of shelled corn does it hold? How many heaped baskets of ear corn?*

PERCENTAGE

A considerable portion of the arithmetical operations demanded in the business world is included in a system termed *Percentage.*

This system is but an application of the three problems of fractions (page 29) in which the fraction is one or more hundredths. The fraction is usually expressed decimally. Hence Percentage is based upon the subject of fractions and decimals. For the term hundredths, *per cent* is substituted. $\frac{7}{100}$ is termed 7 per cent and may be expressed 7%, .07, or $\frac{7}{100}$. 120 per cent is expressed 120%, 1.20 or $\frac{120}{100}$.

Rate is a term used to designate this fraction whether expressed as per cent or hundredths; as, 8%, $\frac{8}{100}$ or .08.

The *base* is the number upon which the per cent is reckoned. In the example to find 7% of 160, 160 is the base.

*1.6 cu. ft. make a heaped basket of ear corn. 1.8 cu. ft. of ear corn make 1 bu. of shelled corn.

Percentage is the product of the rate by the base. In the example to find 5% of 125, the answer, 6.25, is the percentage.

PROBLEM I

The simplest and most commonly used problem of percentage is:

To find a given per cent of a number.

Find 5% of 125.

SOLUTION: 1% of 125 means $\frac{1}{100}$ of 125 which equals 1.25; 5% of 125 equals 6.25; or, $5\% \text{ of } 125 = .05 \times 125 = 6.25$.

Rule: *To find a given per cent of a number, multiply the number by the given rate.*

MENTAL PROBLEMS

Find 3% of 12; 6% of 24; 10% of 17; 25% of 40; 11% of 36; 8% of 360; $33\frac{1}{3}\%$ of 96; $14\frac{2}{7}\%$ of 21.

In the last two examples the work can be abbreviated by reducing the rate to a common fraction; as, $33\frac{1}{3}\%$ of $96 = \frac{1}{3}$ of $96 = 32$. $14\frac{2}{7}\%$ of $21 = \frac{1}{7}$ of $21 = 3$.

The equivalents of the following rates should be memorized:

$.33\frac{1}{3} = \frac{1}{3}$, $.66\frac{2}{3} = \frac{2}{3}$, $.25 = \frac{1}{4}$, $.75 = \frac{3}{4}$, $.16\frac{2}{3} = \frac{1}{6}$,
$.83\frac{1}{3} = \frac{5}{6}$, $.14\frac{2}{7} = \frac{1}{7}$, $.12\frac{1}{2} = \frac{1}{8}$, $.37\frac{1}{2} = \frac{3}{8}$, $.11\frac{1}{9} = \frac{1}{9}$,
$.62\frac{1}{2} = \frac{5}{8}$, $.87\frac{1}{2} = \frac{7}{8}$, $.9\frac{1}{11} = \frac{1}{11}$, $.8\frac{1}{3} = \frac{1}{12}$, $.7\frac{1}{7} = \frac{1}{14}$,
$.6\frac{2}{3} = \frac{1}{15}$, $.6\frac{1}{4} = \frac{1}{16}$.

In solving problem I when these rates are involved, the work should be shortened by using the fractional equivalent. (Compare with page 44.)

Find $6\frac{2}{3}\%$ of 300; of 75; of 45.

Find $14\frac{2}{7}\%$ of 168; of 315; of 18; of 76.

Find $83\frac{1}{3}\%$ of 36; of 42; of 143; of 564.

Find $87\frac{1}{2}\%$, $62\frac{1}{2}\%$, $66\frac{2}{3}\%$, $33\frac{1}{3}\%$, $83\frac{1}{3}\%$, of 1728.

WRITTEN PROBLEMS

1. A Guernsey cow averaged 45 lbs. of milk a day during June, which tested 4%. How many pounds of butter-fat did she produce during the month?

2. A farmer delivered at a factory during a month 7,516 lbs. of milk which tested $4\frac{1}{5}\%$. For what amount of butter-fat should he be paid? What was it worth @ $28\frac{1}{2}$c. a pound?

3. Find 23% of 1,684, 133, 8,432, 146.

4. Find 1.32 of the numbers in the preceding example.

5. Ear corn, while drying, shrinks in weight in the crib on an average 3% a month. A man cribbed 27.5 tons of corn, Oct. 1st. If sold January 1, what could it be expected to weigh? If offered $20 a ton October 1st, for how much must it be sold per ton January 1st to make a profit of $1 per ton for holding it?

6. Nitrate of soda, a commercial fertilizer, has 15% of nitrogen. How many pounds of nitrogen are in 12.5 tons?

PROBLEM II

II. *To find what per cent one number is of another.*

What per cent is 3 of 4?

SOLUTION: $3 = \frac{3}{4}$ of 4. (Page 30 Problem II.) $\frac{3}{4} = 75\%$ $\therefore$ 3 = 75% of 4. Verify by finding 75% of 4.

5 is what per cent of 6?

SOLUTION: $5 = \frac{5}{6}$ of 6. $\frac{5}{6} = 83\frac{1}{3}\%$. $\therefore$ $5 = 83\frac{1}{3}\%$ of 6.

13 is what per cent of 17?

SOLUTION: $13 = \frac{13}{17}$ of 17, $\frac{13}{17}$ reduced to hundredths $= 76\frac{5}{17}\%$.

Rule: *To find what per cent one number is of another, find what part the first is of the second and reduce to hundredths.*

PROBLEMS

1. Find what per cent 8 is of 15; 9 is of 20; 4 is of 9; 3 is of 10; 16 is of 15; 12 is of 7; 18 is of 11; 1,234 is of 6,325.

Find the per cent $2\frac{2}{3}$ is of $3\frac{4}{5}$.

SOLUTION: The part $2\frac{2}{3}$ is of $3\frac{4}{5} = \frac{2\frac{2}{3}}{3\frac{4}{5}} = \frac{8}{3} \times \frac{5}{19} = \frac{40}{57} = 70\frac{10}{57}\%$ $\therefore$ $2\frac{2}{3}$ is $70\frac{10}{57}\%$ of $3\frac{4}{5}$.

2. Find the per cent $3\frac{1}{2}$ is of $4\frac{2}{3}$; $\frac{2}{3}$ is of $\frac{3}{4}$; $5\frac{1}{2}$ is of $3\frac{3}{4}$; 12 is of $4\frac{1}{2}$.

3. One cow yields 24 lbs. of $3\frac{1}{2}\%$ milk daily, and another cow 45 lbs. of 4% milk. From the standard of fat production what per cent is the value of the first cow compared with the value of the second? The second is worth how many times the first, not considering beef value?

4. If a farm is valued at $10,000 and the net income is $800, what per cent does the farm yield on the investment?

5. If it costs $75 to raise a colt to the age of 4 yrs., what is the per cent of profit if it is sold for $140?

PROBLEM III

III. *To find a number when a certain per cent of it is given.*

4 is 8% of what number? (Page 30, problem III.)

SOLUTION: Since 8% of the number is 4, 1% of the number $= \frac{1}{8}$ of 4 or $\frac{1}{2}$. Since $\frac{1}{2}$ is 1% of the number, the number, or $\frac{100}{100}$ of the number, $= 100 \times \frac{1}{2} = 50$, $\therefore$ 4 is 8% of 50. Verify by finding 8% of 50, or by finding what per cent 4 is of 50.

15 is 75% of what number?

SOLUTION: $\frac{15 \times 100}{75} = 20.$

Rule: *To find a number when a certain per cent of it is given, multiply the number by 100 and divide by the per cent.*

PROBLEMS

1. 30 is 10% of what number? 45 is 9% of? 18 is 3% of? 16 is 8% of? 24 is 12% of? 750 is 15% of?

2. Solve, having the answer correct to two decimal places: 36 is 7% of? 18 is 11% of? $\frac{3}{5}$ is 13% of? 143 is 36% of? 216 is 13% of?

3. What sum must be invested to produce \$1,000 at 4%?

4. As an income producer at 6%, what is a cow worth that produces on an average 11,325 lbs. of $4\frac{1}{5}$% milk worth 30c. per pound of butter-fat for 6 yrs., at a total expense of \$80 per year?

SUGGESTION: She must produce her value in 6 years, together with 6% on her value as an investment.

5. A man rented his farm for \$720, which was 8% of its valuation. At what did he value the farm?

6. Received \$640 interest at 5%. Find the principal.

INTEREST

When a person loans money, he receives for its use or rent a certain sum of money.

The money loaned is the *principal* and money paid for its use is the *interest*.

The interest is usually reckoned at a certain per cent for a year. This per cent is the *rate*.

Where many problems in computing interest have to be solved, interest tables are used. But the following general method is probably the best for all kinds of examples. It is better to teach one general rule than to direct the pupil's attention to several in order that he may select the best one when he needs to apply it.

MENTAL PROBLEMS

Find the interest on \$600 at 5% for 1 yr.; \$350 at 4% for 2 yrs.; \$150 at 8% for 1 mo.; \$375 at 6% for 6 mo.

WRITTEN PROBLEMS

Find the interest on $875 for 2 yrs., 6 mo. at 7%.

SOLUTION:

875	
.07	
61.25	1 yr.
2	
122.50	2 yrs.
30.62	6 mo.
153.12	

2. Find the interest on $500 for 2 yrs., 3 mo. at 4%.

3. $327 at 5%, 1 yr. and 9 mo.

4. $1,436 at 7% for 2 yrs., 7 mo.

5. $875 for 3 yrs. 6 mo. at 5%

6. Find the interest on $500 for 2 yrs., 3 mo. at 4%.

7. $327 at 5%, 1 yr. and 9 mo.

8. Find the interest on $1,436 at 7% for 2 yrs., 7 mo., 11 da.

SOLUTION:

1436	
.07	
100.52	1 yr.
2	
201.04	2 yrs.
50.26	6 mo.
8.37	1 mo.
2.79	10 da.
.28	1 da.
262.74	

9. What is the interest of $150 at 5% for 1 yr., 11 mo., and 21 da.?

150	
.05	
7.50	1 yr.
.62	1 mo.
6.25	10 mo.
.43	21 da.
14.80	

SOLUTION: Having found the interest for 1 mo. by dividing the interest for 1 yr. by 12, multiply by 10 by moving each figure of 1 mo's. interest one order to the left. In finding the interest for 21 da., multiply one month's interest by 7, placing the result one order to the right; for 21 da. is $\frac{7}{10}$ of one month; i. e. divide by 10 and multiply by 7.

The interest for any number of days that is a multiple of three can thus be obtained. $18 = \frac{6}{10}$, $12 = \frac{4}{10}$, etc.

By this general rule, every figure of the partial interest is expressed in a compact body with the results ready for addition.

Find the interest of:

10.	$842	6%	1 yr.	7 mo.	12 da.
11.	$365	4%	3 yrs.	8 mo.	15 da.
12.	$1,216	5%	1 yr.	8 mo.	17 da.
13.	$450	8%	2 yrs.	3 mo.	14 da.
14.	$720	6%	1 yr.	1 mo.	9 da.
15.	$486	3%	2 yrs.	5 mo.	27 da.

MISCELLANEOUS PROBLEMS

1. If wheat weighed 2,760 lbs. when put in the bin and in the spring weighed 2,484 lbs., what per cent of the former weight did it decrease? If worth 92c. per bushel in the fall, for how much per bushel must it be sold in the spring to give a 6% profit for holding?

2. I was offered $400 cash for a team of horses, but decided to send them to a Chicago sale stable. They were sold after two weeks for $500. Charges: $25 freight, $1 per day each for board, commission 4%. Which bargain was the better and how much?

3. Bought a bunch of pigs for $1,400 at 7c. a pound. I kept them 5 months and fed them 2,500 bu. of corn at 40c. per bushel and $200 worth of other feed. They gained 125% in weight and were sold at 8c. a pound. If I borrowed the purchase money at 8%, what was my profit in the transaction?

4. In example 3, what was my per cent of gain, the feed being paid for when pigs were sold?

5. A note of $245 dated January 12, 1912, with interest at 6%, was paid July 18, 1914. How much was due at the

latter date, no interest having been previously paid? Write the note if payable to John Doe signed by Richard Graham.

6. Capitalize the value of a hen that for 2 years produces $1.25 per year at an annual expense of 65c.

SUGGESTION: If she is worth 50c. for meat, add that sum to get her true value.

7. Capitalize the value of a cow that produces 12,020 lbs. of milk testing at 4.2%, butter-fat worth 30c., for 5 yrs. at an annual expense of $83.50, worth $65 for beef.

8. Suppose in example 7 the cow averages 6,000 lbs. of 3% milk, at an expense of $55 for feed, what is she worth?

RATIO AND PROPORTION

The *ratio of one quantity to another* is the quotient obtained by dividing the first by the second.

The ratio of 2 to 1 is 2; of 9 to 3 is 3; of 3 to 4 is $\frac{3}{4}$, of 7 to 8 is $\frac{7}{8}$; 1 in. to 4 in. is $\frac{1}{4}$; 7 yds to 9 yds. is $\frac{7}{9}$; of 6 bu. to 3 bu. is 2.

A *proportion* is a statement of equality of two ratios; as, $\frac{3}{4} = \frac{6}{8}$, the ratio of 6 to 3 = the ratio of 8 to 4.

The *extremes* of a proportion are the first and last terms; the *means* are the second and third terms.

In the proportion $\frac{8 \text{ ft.}}{12 \text{ ft.}} = \frac{24 \text{ yds.,}}{36 \text{ yds.,}}$ 8 ft. and 36 yds. are the extremes and 12 ft. and 24 yds. are the means.

The extremes may be used in computation as 8 and 36, the means 12 and 24. The proportion $\frac{8 \text{ ft.}}{12 \text{ ft.}} = \frac{24 \text{ yds.}}{36 \text{ yds.}}$ numerically is the same as $\frac{8}{12} = \frac{24}{36}$.

An important working **principle** of proportion is: *The product of the means equals the product of the extremes.*

1. If two quantities have the ratio of 5 to 7; two other quantities have the same ratio, and the first term of the second ratio is 15, what is the other term?

2. Find x in the proportion $\frac{5}{7} = \frac{15}{x}$.

SOLUTION: $x = \frac{7 \times 15}{5} = 21.$

Find x in the proportions: $\frac{x}{20} = \frac{3}{10}$; in $\frac{9}{13} = \frac{x}{20}$; in $\frac{6}{x} = \frac{18}{31}$; in $\frac{3}{4} = \frac{19}{x}$.

A proportion may be stated $3 : 12 = 4 : 6$ and is read 3 is to 4 as 4 is to 6.

Find x in the proportions $3 : 7 = 9 : x$; $\frac{2}{3} = \frac{4}{x}$; $6 : 7 = 9 : x$; $2\frac{1}{2} : 5 = x : 3\frac{2}{3}$.

Cement, sand, and gravel are frequently mixed in the proportion of 1, 3, and 7 by bulk. If a bag of cement is used, what amount of sand and gravel should be mixed with it? Assume a bag of cement $= 1$ cubic foot. If mixed in the proportion of 1, 3, and 5, how many yards of sand and gravel should be used to 2 barrels of cement? (1 bbl. = 4 bags.)

Principle I: *The ratio of any two surfaces equals the ratio of their areas or the products of their dimensions.*

3. Two rectangles are 4 by 12 and 3 by 8. What is their ratio?

SOLUTION: Their areas are respectively 48 and 24 $\therefore$ the ratio of the first rectangle to the second is $\frac{48}{24} = 2$ or $\frac{4 \times 12}{3 \times 8} = 2.$

4. What is the ratio of two squares whose sides are respectively 4 and 6? 4 and 2? 1 and 4?

Principle II: *Circles have the ratio of the squares of their radii.*

5. One circle is 4 times the area of the other. If the radius of the smaller circle is one, what is the radius of the other?

SOLUTION: $\frac{1}{4} = \frac{1}{x^2}$; $x^2 = 4$, $x = 2$ (page 51).

6. If the areas of two circles are as 1 to 9, what is the ratio of the radii?

SUGGESTION: Use 1 for the radius of the first and x for radius of the second.

7. If the radii of two circles are in the ratio of 1 to 4; compare their areas. If radii are in ratio of 1 to 3.

8. The radii of two circles are as 1 to 2. Compare their areas.

9. Two circles have radii 5 and 7. Determine their ratio.

10. If one circle is twice another, compare their radii.

SOLUTION: The ratio of their areas is $\frac{2}{1}$ $\therefore$ $\frac{2}{1} = \frac{x^2}{1^2}$ $\therefore$ $x^2 = 2$ $\therefore$ $x = \sqrt{2} = 1.414+$

Principle III. *The ratio of any two solids equals the ratio of their volumes or the ratio of the products of their dimensions.*

11. The edges of two cubes are 1 ft. and 2 ft. respectively. How do their volumes compare? If the edges are 1 and 3 ft., compare their volumes.

12. The radii and altitude of one cylinder are each one half those of another; compare their volumes.

SUGGESTION: Use 1 and 2 for their respective dimensions and compare their volumes. (Page 60.)

13. If the edges of two cubes are in the ratio of 1 to 4; of 1 to 5; of 1 to 6; compare their volumes.

MISCELLANEOUS PROBLEMS

14. One pine log has twice the diameter and three times the length of another. The smaller produces 60 ft. of lumber. How much will the other produce, if sawed into the same dimension lumber?

15. One silo has twice the diameter and twice the altitude of another. How does the first compare with the second in capacity?

16. If the smaller contains 1,056 cu. ft., what is the capacity of the other?

17. The area of a circle is $81\frac{3}{7}$ sq. ft. What is its radius?

18. The ratio of two numbers is as 5 to 7 and their sum is 96. What are the numbers?

SUGGESTION: One is $\frac{5}{12}$ and the other $\frac{7}{12}$ of 96. Why?

19. Two men are to divide a crop of corn, 1,500 bu., so that one will have one half as much as the other. How many bushels should each have?

20. A sale of cattle for $2,842 is to be divided so that one partner will have $\frac{3}{4}$ as much as the other. What is the share of each?

SUGGESTION: What is the ratio of their shares?

21. How shall I divide a 48-in. evener or doubletree so that one horse will draw one half as much as the other?

SUGGESTION: The amount of draft is in inverse ratio to the length of the arms of the doubletree.

22. How divide it so that one horse will draw $\frac{3}{5}$ as much as the other? To which end should the weaker horse be hitched?

23. If one apple is 2 in. in diameter and another is 3 in., how many times as large as the first is the second?

24. One cylindrical tank has a radius of 7′ and depth of $2\frac{1}{2}$′, another a radius of 5′ and depth of $3\frac{1}{2}$′. What is the ratio of the first to the second?

25. The price of $2\frac{1}{2}$-in. oranges, pulp measure, is 40 cents per dozen; of 3-in. oranges is 50 cents. If of the same quality, which is better to buy? What is the real value of the larger oranges at the rate of the smaller? Of the smaller at the rate of the larger?

PART TWO

CHAPTER I

FARM CROPS

The first great business of the farmer is to raise crops. The world must be fed and clothed, and it is he who provides the bulk of the raw material which is manufactured into food stuffs and clothing. Without the farmer commerce would cease. From the ever increasing city population comes the cry for bread even more urgent. There will always be cities, and thus the farmer will always find a market for his farm produce. The successful farmer is an artisan who skillfully combines the art and science of farming with business and enterprise.

ORAL PROBLEMS

1. A man produced 425 bushels of oats from five acres. What was the yield per acre?

2. Another man produced 156 bushels from 13 acres. What was the yield per acre?

3. In your state what is the weight of
   (a) 6 bushels of shelled corn?
   (b) 5 bushels of corn on cob?
   (c) 2 bushels of oats?
   (d) 9 bushels of potatoes?
   (e) 7 bushels of wheat?
   (f) 5 bushels of rye?
   (g) 6 bushels of onions?

4. 350 pounds of cured corn on the cob is equivalent to how many bushels of shelled corn? (See page 242.)

5. How many acres will 45 bushels of rice plant, when sowing is done at the rate of $1\frac{1}{2}$ bushels per acre?

6. At the rate of 10 bushels per acre, how many bushels of seed potatoes will be required for $\frac{3}{4}$ of an acre?

7. At the rate of five pecks per acre, how many bushels of cowpeas are required to sow 12 acres?

8. What is the weight of 4 quarts of timothy seed in your state?

9. Seeding 12 pounds of red clover seed per acre is equivalent to seeding how many quarts per acre?

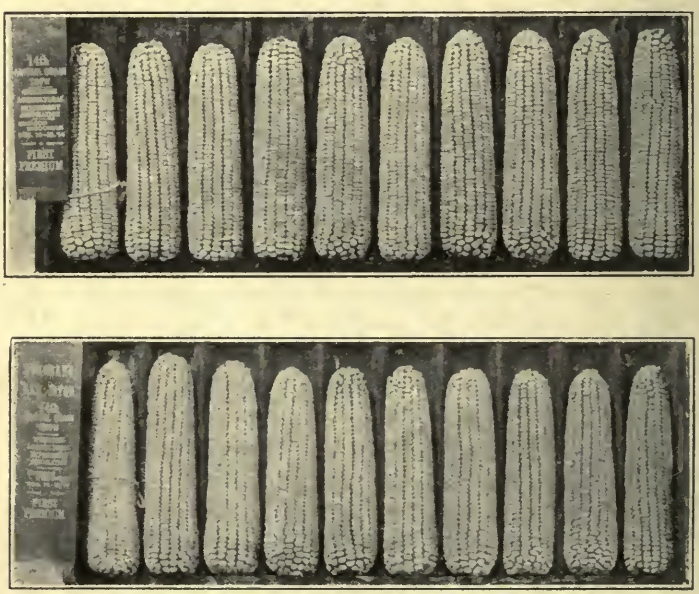

Figure 1.—Corn,—The Greatest Crop in the United States. If one has never taken any interest in plants, one should study corn. Some of the wonders of creation will be revealed.

Courtesy of Wis. Agr'l Exp. Ass'n.

10. Hay that averages 30 pounds per square rod yields how many tons per acre?

11. How many more pounds in 2 bushels of potatoes than in 2 bushels of oats?

12. 3 bushels of shelled corn is equivalent in weight to how many bushels of oats?

13. $33\frac{1}{3}$ per cent of $\frac{3}{8}$ of a bushel of barley in Wisconsin is equal in weight to what part of a bushel of beans?

WRITTEN PROBLEMS

1. According to government statistics, 105,820,000 acres of corn were raised in the United States in 1913, producing 2,446,988,000 bushels. What was the average yield of corn per acre in the United States for that year?

2. What was the average yield of corn in your state for that year? What is the average yield on your farm or in your community?

3. Official statistics show that the grand total corn crop of the world for the year 1913 was approximately 3,605,442,000 bushels. What per cent of the world's crop was produced in the United States during that year?

4. How much of the nation's wealth was represented by its corn crop December 1, 1913, when the average farm price per bushel was 69.1 cents?

5. Statistics show that the average acre wheat yield of the United States for the nine years 1905 to 1913, inclusive, is only 14.6 bushels and that of Germany for the same period is 30.7 bushels. The average wheat yield of Germany is what per cent of that of the United States?

6. The population of the United States in 1910 was 92 millions; in 1890 it was 63 millions. What was the per cent of increase in the twenty years?

(a) The rural population in 1890 was 63.9%; in 1910 it was 53.7%. What was the per cent of decrease in rural population during these two decades?

7. The average annual acreage of corn, wheat, oats, barley, rye, and buckwheat during the five years from 1906 to 1910, inclusive, was 210,935,000 acres; for the five years from 1886 to 1890, inclusive, it was 144,141,000 acres. Did the per cent of acreage increase keep pace with the per cent of increase in population during that period? Can this per cent of acreage increase continue very long? Why?

8. From the data given in Figure 2 determine the decrease in the average number of bushels of corn and other grains exported annually from the United States from the banner five-year period, 1896 to 1900 inclusive, to the average for the five years from 1906 to 1910 inclusive.

9. When we consider the facts brought out in problems 6, 7 and 8, what greater responsibility is placed upon the farmers of this country?

10. The estimated production of cotton in China in 1912 is 4,000,000 bales. This quantity is 29.18% of the total production in continental United States for the same year. How many bales of cotton were produced in the United States in 1912?

Figure 2.—Decrease in Exportation of Grain from the United States.

11. Texas produces more cotton than any other state. The total crop for the United States in 1912 was 188% more than that produced by Texas alone. How many bales of cotton did Texas produce in 1912?

12. A grain farmer sold 30 tons, or $\frac{3}{8}$ of his wheat crop, at 90 cents per bushel, and the remainder for 91.5 cents per bushel. How much did he get for his crop?

13. "A" produced from 8 acres, 1,680 pounds of clover seed, or $2\frac{1}{2}$ times more than his neighbor from an equal area. What was the yield in bushels per acre of clover seed on each of the two farms?

14. An acre of corn carefully planted should average at least 3 stalks to the hill which are generally planted 44 inches apart each way.

(a) How many square feet are allowed for each hill? Draw a diagram to illustrate this.

(b) How many hills does one acre of this corn contain?

(c) A quart of average dent corn contains about 2,500 kernels. How many quarts of seed corn are required to plant this acre? (Allow a little extra for overrun.) How many pounds?

(d) At this rate how many bushels of corn are required to plant 30 acres? How many pounds?

15. If the corn were planted in drills 3 feet apart and averaging one stalk per foot in the row, how much corn would be required to plant an acre? How many quarts? Pounds?

16. Good average seed corn contains from six to seven hundred kernels per ear suitable for planting, tips and butts excluded. How many ears would be required to plant an acre described in problem 14?

17. How many ears would be required to plant an acre described in problem 15?

18. Illinois Station demonstrated that on rich soil the greatest amount of total digestible food substances (pro-

tein, carbohydrates and fats) were secured per acre in growing dent corn when the kernels were planted 3 inches apart in the row and the rows 3 feet 8 inches apart.

(a) How many kernels are required to plant an acre of such corn?

(b) About how many quarts? Pounds?

(c) About how many ears of good seed corn?

19. 4.8 tons of stover were produced per acre in the test described in problem 18, or 3.6 pounds of stover for each pound of shelled corn. How many bushels of shelled corn were produced per acre?

20. A farmer growing dent corn on rich soil found he could get best results by planting 4 kernels in the hill and the hills placed 3 feet 8 inches apart each way. He secured 74.8 bushels of shelled corn per acre. The ratio of field cured stover to corn on cob was 1.3 to 1.

(a) How much seed corn was required to plant an acre of this corn?

(b) How many tons of stover were produced per acre?

21. In one gram of good alfalfa seed are 475 seeds. How many seeds are sown per square foot when 20 pounds are evenly distributed over one acre? (See page 246.)

Fifteen plants per square foot may be regarded an excellent "catch" and 6 to 9 per square foot a good "producing stand." What becomes of the rest of the seed planted? Should less seed be sown per acre?

22. Shelled corn at 70 cents per bushel is equivalent to how much per ton?

23. A farmer received $600 for 16 tons of oats. How much did he get per bushel?

24. A man secured barley at $25 per ton when the market quotation was 65 cents per bushel. Did he give more or less per ton as compared with market quotation, and how much?

Figure 3.—A Good Crop of Alfalfa. Leguminous crops of all kinds not only furnish abundant supply of protein and mineral matter for animal needs, but help to maintain the fertility of the soil by gathering nitrogen from the air.

25. 10,500 pounds of corn on cob were placed in a crib when husked. After a year's time 119.25 bushels were taken from the crib as the total content. What was the per cent shrinkage of the ear corn?

(a) When the corn is worth 40 cents at time of cribbing, what should it be worth per bushel when removed to compensate for the shrinkage?

26. 100 pounds of potatoes containing 17% starch would yield approximately 1.3 gallons of denatured alcohol. How many quarts would one bushel yield?

(a) How many gallons would one acre yield when 220 bushels are harvested averaging 20% starch?

27. Cabbage plants are usually set in rows about 30 inches apart and 13 to 18 inches apart in the row. How many tons would an acre yield when a perfect stand is secured, if plants are 15 inches apart in the row, and each head averages 4 pounds?

(a) Estimate without use of pencil the yield of cabbage per acre when the rows are 30 inches apart; the plants were set 20 inches apart in the rows, but every third plant on an average failed to grow. The heads averaged 4 pounds. Check your estimate.

(b) Make another estimate for conditions same as in (a) only that the heads averaged 3 pounds. Check your estimate.

28. Estimate the yield of shelled corn per acre when corn is standing ripe, is planted in hills 3 feet 8 inches each way, and one hill out of seven is missing. The stalks standing average 3 one-pound ears per hill. Deduct 30% for moisture.

Points of Interest:

1. The farmers feed the world.

2. The United States with her expanses of "new" soil falls far below Germany in production of wheat per acre.

3. Better agriculture is a national necessity.

Name other points of practical value brought out in Chapter I.

CHAPTER II

FARM ANIMALS

As far back as we can go in human history we find that domestic animals have played an important role in the development of civilization. Man and the cow, as it were, seem to have been rocked in the same cradle. The economic importance of domestic animals ascends to large proportions when we consider their use for food, clothing and labor.

Figure 4.—A Good Type of a Draft Horse (Clydesdale). An animal like this is never reared by the careless. Courtesy of Wis. Live Stock Ass'n.

WRITTEN PROBLEMS

1. The 1910 census reports the following numbers and values as applied to domestic animals on the farms in the United States for that year:

Class of Stock	*Number*	*Value*
Horses	19,833,000	$2,083,588,000
Cattle	61,804,000	1,499,524,000
Mules	4,210,000	525,392,000
Swine	58,186,000	399,338,000
Sheep	52,448,000	232,842,000

What is the total number and value of these farm animals?

2. If 10 men can each count silver dollars at the rate of 60 per minute, how many years would it take them,

Figure 5.—A Good Type of Percheron Mare.
Courtesy of Wis. Live Stock Ass'n.

working 8 hours per day and 300 days in a year, to count a number of dollars equal to the amount invested in these farm animals?

3. What was the average value of cattle per head?

4. Compare the average value of horses per head with that of mules.

5. What value was placed on swine per head? On sheep?

6. What is the value per head of these various farm animals in your community?

7. In 1911, nearly 272,000 car loads of live stock were received in the Union Stock Yards of Chicago. What was the average number of carloads received per day?

8. The average person in the United States eats about 180 pounds of meat a year. What is the average amount eaten per day?

9. The champion Jersey cow (1914), (Sophie 19th of Hood Farm), produced 999.14 pounds of butter-fat in 365 days. Her milk tested 5.69% fat.

(a) How many pounds of milk did this cow produce in a year? Average per day?

(b) How many pounds of butter testing 85% butter-fat? Average per day?

10. The champion Ayrshire cow (1914), (Auchenbrain Brown Kate 4th), produced in one year enough butter-fat to make 1,070.6 pounds of butter, containing 85.7% butter-fat. Her milk tested 3.99% fat. How many pounds of milk were produced during the year's test? What was the average per day?

11. The once champion Holstein cow of the world, Banostine Belle De-Kol (May 1, 1914) produced 27,404

Figure 6.—Auchenbrain Brown Kate IV. A former world's champion Ayrshire. (See problem 10, page 87.) Courtesy of Wis. Live Stock Ass'n.

pounds of milk in one year, testing 3.86% butter-fat. Determine the value of the milk produced at 6 cents per quart.*

12. May Rilma (Guernsey) produced in one year 19,673 pounds of milk, testing 5.45% butter-fat. How many more pounds of butter-fat were produced by this cow than by the champion Holstein?

13. Murne Cowan, the champion Guernsey cow of the world and for a time the champion of all breeds, completed her record February, 1915, after producing 24,008 pounds of milk, testing 4.57% in 365 days.

(a) Determine the value of the milk produced at 6 cents per quart.

(b) How many pounds of milk did she produce per day on an average? Quarts per day?

*1,000 pounds of milk = 465 quarts, or 1 gallon = 8.59 pounds.

(c) How many more pounds of butter-fat did this champion cow produce than May Rilma, the world's champion before her?

14. When Finderne Holingen Fayne, a 3-year-old Holstein cow, finished her record March, 1915, she won the world's championship* of all the breeds. She produced 24,612.8 pounds of milk yielding 1,116.05 pounds of butter-fat.

(a) Determine the average test of this cow's milk.

(b) How many gallons of milk did this cow produce per day on an average?

15. Compare the average daily production of milk of May Rilma, Murne Cowan and Finderne Holingen Fayne. Average daily production of butter-fat. Yearly production of milk and butter-fat.

Figure 7.—Murne Cowan. The champion Guernsey cow of the world. (See problem 13, page 88.) Courtesy of Wis. Live Stock Ass'n.

*See page 228, problem 27.

16. Tilly Alcartra (Holstein) produced 30,452.6 pounds of milk in 365 days—the most milk ever produced by one cow in one year. She produced 1,189 pounds of butter containing 80% butter-fat.

(a) What was the average amount of milk produced in a day? Pounds? Quarts?

(b) What was the average test of this cow's milk?

17. How many pounds of milk do the cows in your neighborhood or on your farm produce daily? Per year?

(a) How many such cows would be required to produce as many pounds of butter-fat in one year as were produced by Finderne Holingen Fayne?

CHAPTER III

FEEDS AND FEEDING PRACTICE

To eliminate guessing in feeding, the farmer must have a clear understanding of the needs of the various animals on his farm, and he must know the comparative feeding value of the many feeds. All this demands study. Food value of feeds is determined by their composition which is usually expressed by the following substances: water, ash*, protein, crude fiber, nitrogen-free extract and fat. Nitrogen-free extract includes sugars, starches and gums. The group-term carbohydrates is commonly used to include the nitrogen-free extract and crude fiber.

ORAL PROBLEMS

1. Dent corn contains 10.5% water. What per cent dry matter does it contain?

2. Oats contain 9.2% water. How many pounds of dry matter in 100 pounds?

3. Cowpea hay consists of 9.7% water. How many pounds of water in one ton?

4. Fresh pasture grass is 80% water. How many pounds of water are consumed when a cow eats 70 pounds of grass a day?

5. If a bushel of wheat were burned, 1.9% of it would remain as ash (ashes). How many pounds of ash would be left?

6. Thirteen and six tenths per cent is the ash content of alfalfa leaves. How much ash is contained in 60 pounds of leaves?

*Ash is commonly referred to as mineral or inorganic matter.

7. Wheat bran analyzes 6.3% ash. How many pounds of mineral matter are contained in 1,000 pounds of bran?

8. Cottonseed meal consists of 6.4% ash. How many pounds of inorganic matter are contained in $\frac{1}{4}$ of a ton?

9. Cottonseed meal contains 8.2% fat. How many pounds of oil in 80 pounds of cottonseed meal?

10. Corn stover contains 5.9% protein. How many pounds of this flesh-producing substance are contained in half a ton of corn stover?

11. 14.9% of the weight of alfalfa hay is protein. How many pounds of this flesh and milk-producing substance are contained in 1,000 pounds?

12. Oil meal (linseed meal) analyzes 7.5% fat. How many pounds of fat in 2 tons?

13. Oat straw contains 36.3% crude fiber and alfalfa hay 28.3%. How many more pounds of crude fiber, or woody fiber, are contained in 200 pounds of oat straw than in the same amount of alfalfa hay?

14. Oat straw contains 40.8% nitrogen-free extract, and alfalfa hay 37.3%. How many pounds of *carbohydrates** are contained in 100 pounds of oat straw? In 100 pounds of alfalfa hay?

WRITTEN PROBLEMS

1. By consulting table on "Composition of Common Feeds" in the appendix (page 235), determine the number of pounds of ash, or mineral matter, contained in 2 tons each of dent corn, alfalfa hay, red clover hay and oat straw.

2. How many more pounds of crude protein are contained in 3 tons of alfalfa hay than in the same amount of timothy hay?

*Carbohydrates is the sum of the crude fiber and nitrogen-free extract. (See introduction to Chapter III.)

3. Only 3 pounds of crude protein out of 100 pounds of timothy hay can be digested by farm animals, while 10.6 pounds of protein in every 100 pounds of alfalfa are digestible. (See page 247.) What per cent is the amount of digestible protein contained in one ton of alfalfa hay of that in a ton of timothy hay? Which would you rather feed to a dairy cow, alfalfa or timothy? Why? What per cent of the total crude protein in alfalfa hay is digestible? In timothy?

4. Which contains more digestible protein, one ton of alfalfa hay or one ton of red clover hay? How much more?

5. How many times is the digestible protein contained in 4 tons of cottonseed meal that in the same amount of gluten feed?

6. A farmer bought 20 bushels of shelled dent corn.
   (a) How many pounds of crude fiber did he buy?
   (b) How many pounds of nitrogen-free extract did he buy?
   (c) How many pounds of carbohydrates?
   (d) How many pounds of digestible carbohydrates are contained in this amount of corn? (See page 247.)

7. What is the difference in the amounts of digestible carbohydrates contained in 5 tons each of oat straw and timothy hay? How would good oat straw do for winter horse feed?

8. How many acres of alfalfa yielding 5 tons of hay per acre per year are required to produce as much digestible protein as is produced by 30 acres of timothy yielding 2 tons of hay per acre?

9. Five tons of corn silage contain as much digestible carbohydrates as is contained in how many tons of sugar beets?

10. How many pounds of fat, or oil, are contained in 25 bushels of shelled corn? How many pounds of digestible fat?

11. How many pounds of nutrients* are contained in 1,000 bushels of oats? Digestible nutrients?

Figure 8.—A Well Bred and Thrifty Family. Successful management of swine depends largely upon the man behind the swill cart.
Courtesy of Wis. Exp. Sta.

12. Ten tons each of wheat bran and cottonseed meal are piled separately in two piles. Which pile of feed contains the greater amount of nutrients? How much more?

13. Compare the amount of nutrients in 3 tons of alfalfa hay with that contained in 3 tons of wheat bran.

14. Determine the amount of digestible nutrients in one ton each of alfalfa hay, wheat bran and cottonseed meal. Place these three feeds in the order of the amount of digestible nutrients they contain.

**Nutrients*—a term commonly used, when feeds are considered, to include *crude protein*, *carbohydrates* and *fats*; although air, water and mineral matter might likewise be so termed.

15. A man purchased 15 tons of alfalfa hay at $10 per ton. Would he have purchased as much digestible crude protein, carbohydrates and fats had he purchased the same amount of good sweet clover hay at the same price?

16. A dairyman went out to buy some hay for his cows. He had a choice between 7 tons of good alfalfa hay for $107 and 11 tons of good red clover hay for $110. He purchased the hay which gave him the larger amount of total *crude protein* to the dollar. Which hay did he purchase and how much more crude protein did he get for every dollar spent?

(a) From the standpoint of *digestible* crude protein, did this dairyman purchase wisely? What was the difference in amount of digestible crude protein purchased for one dollar?

(b) Could he have purchased more total nutrients had he purchased the other hay? The difference is in favor of which hay?

(c) Some feeding tests have demonstrated that one pound of alfalfa hay, in feeding dairy cattle, is equal to 1.6 pounds of red clover hay in producing results. From this standpoint which would have been the cheaper hay? How much cheaper?

17. When alsike clover is worth $8 a ton, what ought crimson clover to be worth on the basis of digestible crude protein?

18. 1,000 pounds of shelled corn contain $\frac{3}{10}$ of a pound of lime* and 3 pounds of phosphorus. The same amount of alfalfa hay contains 43.1 pounds of lime and 2.4 pounds of phosphorus. How many pounds of bone-building material (lime and phosphorus) are contained in 400 bushels of corn and 5 tons of alfalfa hay?

*Equivalent in quicklime.

19. How much alfalfa hay must be fed in order to feed 84 pounds of digestible crude protein? How many pounds of timothy?

20. How many bushels of barley must be fed in order to feed 326.5 pounds of digestible carbohydrates? How many bushels of corn? Would ground or rolled barley with corn make a good feed for fattening hogs?* Why?

21. How many tons of mangels are required to equal the amount of digestible nutrients contained in 2 tons each of alfalfa and Johnson grass hay? What is the great value of mangels and other roots in feeding, especially when no silage is fed?

22. Cornell Station demonstrated that 1 pound of dry matter in mangels is equal to 1 pound of dry matter in grain in feeding dairy cows.

(a) One pound of dry matter in mangels is equivalent to how many pounds of mangel roots?

(b) One pound of dry matter in dent corn is equivalent to how many pounds of the corn grain?

(c) One ton of mangels in feeding dairy cows is equal to how many pounds of shelled corn in producing results? How many bushels?

23. A farmer had 25 cows and fed them an average of 30 pounds of corn silage for 270 days.

(a) How many tons of silage did he feed during that time?

(b) How many acres were required to produce this silage when the average yield was 12 tons of silage corn per acre?

*Barley alone has about 10% less value than corn for fattening swine. It should never be fed separately, but always in combination with corn, wheat, roots, alfalfa, etc.

(c) When a cubic foot of silage in a silo, 2 days after filling, averages 40 pounds, what is the minimum cubic content of a silo required to contain this amount of feed?

(d) The silo was cylindrical with an inside diameter of 14 feet. What was the depth of the silage 2 days after filling? About how high was the silo, inside measurement? (See page 63.)

(e) About how high ought a 16-foot silo to be to contain this feed?

(f) Which one is the better shape for the above herd? What dimensions would you suggest?*

24. A farm of 120 acres produced all the feed fed to a herd of 30 dairy cows. The average daily ration consisted of 35 pounds of corn silage fed for 11 months, 6 pounds of alfalfa hay fed for 8 months, 5 pounds of clover hay fed for 8 months, 8 pounds of ground oats and barley (equal parts by weight) fed for 9 months.

How many acres were required to produce the amount of feed necessary when the following yields were obtained: corn, 14 tons of green corn; alfalfa, 4.5 tons (3 cuttings); red clover, 2 tons (2 cuttings); barley, 30 bushels; oats, 50 bushels per acre?

25. 850 lambs were fed 112 days on a ration consisting of 2 pounds of mixed grains, 1.4 pounds of corn silage, 1.6 pounds of alfalfa hay. The average gain per lamb during this period was 46.04 pounds.

(a) What was the total number of tons of each feed fed?

*When silage is left exposed to the air for any length of time it spoils. To prevent spoiling in the silo during the time in which it is being used it is necessary to remove a layer of silage to a depth of not less than 1½ inches daily.

(b) What was the average amount of each feed consumed per lamb?

(c) What was the average daily gain for the whole flock? Average per lamb?

(d) How many pounds of feed were necessary to produce 100 pounds of gain?

(e) If alfalfa was worth \$10, corn silage \$3, and mixed grains \$20 per ton, what did it cost in feed to produce a pound of gain?

26. A man had 20 cows. He gave them plenty of good roughage* and fed each cow as many pounds of concentrates† daily as she gave pounds of butter-fat in a week—a simple rule followed by the Wisconsin Station.

The cows produced as follows: 5 averaged 15 pounds of milk each daily, testing 4% butter-fat; 6 averaged 20 pounds each, testing 3.8%; 5 averaged 22 pounds each, testing 4%; 3 produced 20 pounds each of milk daily, testing 4.2%; and one cow averaged 35 pounds of milk daily, testing 3.8% butter-fat.

(a) Determine the number of pounds of concentrates fed each cow daily.

(b) How many pounds of concentrates were required to feed the herd for 30 days?

27. A feeder plans to produce at least 10 pounds of pork per bushel of shelled corn. He has 150 pigs averaging 110 pounds, and plans to market them when they average 225 pounds.

(a) On this basis how many bushels of shelled corn would be required to fit these pigs for the market?

**Roughage* includes the coarser feeding stuffs, such as hay, corn silage, roots, etc.

†*Concentrates* are feeding stuffs of condensed nature, such as grains, bran, cottonseed meal, etc.

(b) This amount of shelled corn is equivalent to how many tons of cured ear corn?

(c) What would be the average amount of shelled corn consumed per pig?

Facts in Feeding:

1. There is a wide variation in the total digestible protein, carbohydrates and fats contained in feeds.

2. Feeds containing much protein are best for flesh and nerve building and for milk production.

3. In knowing the composition of feeds and the needs of animals, the farmer can raise the kind of crops, or buy the feeds, to meet his particular needs in feeding.

CHAPTER IV

THE THEORY OF FEEDING

A great deal of study has been given to animal feeding. Numerous experiments have been made the world over determining the value of feeds and combinations of different feeds for various animals in all stages of growth and for all purposes and uses to which domestic animals are put. These tests have demonstrated that best results are obtained through intelligent and regular feeding. To do this the feeder must know the particular needs of the animals he is feeding and what feeds he can use to best advantage to meet those needs.

WRITTEN PROBLEMS

1. The heat value of digestible fat is 2.25 times that of digestible carbohydrates. 75 pounds of digestible fat in a certain amount of feed is equivalent in heat value to how many pounds of digestible carbohydrates?

2. 8.25 pounds of digestible fat in corn silage is equivalent to how many pounds of digestible carbohydrates?

(a) One hundred pounds of barley contain 66.8 pounds of digestible carbohydrates and 1.6 pounds of digestible fat. Express the total amount of digestible carbohydrates and fat in terms of digestible carbohydrates.

SOLUTION:

Step 1. The heat value of fat is 2.25 times that of carbohydrates, hence the digestible carbohydrate equivalent of 1.6 pounds of fat is 1.6 $\times$ 2.25, or 3.6 pounds of digestible carbohydrates.

Step 2. The sum of 66.8 and 3.6, or 70.4 pounds, is the total amount of digestible carbohydrates and fat expressed in terms of digestible carbohydrates.

3. 100 pounds of germ oil meal contain 42.6 pounds of digestible carbohydrates* and 10.4 pounds of digestible fat. Express the total amount of carbohydrates and fat in terms of digestible carbohydrates; i. e., the equivalent of digestible carbohydrates.

4. Germ oil meal contains 16.5% digestible crude protein. Determine the ratio between the digestible crude protein and the digestible carbohydrates equivalent in this feed; in other words, for every pound of digestible crude protein how many pounds of combined digestible carbohydrates and fats? (Fat reduced to equivalent in carbohydrates.)

The result expresses the nutritive ratio of germ oil meal.

Nutritive ratio of any feed, or ration, is the ratio between the digestible crude protein and the combined digestible carbohydrates and fat—the amount of fat being first reduced to its equivalent in digestible carbohydrates.

The first factor in a nutritive ratio is always 1; the second factor is determined by dividing the total amount of digestible carbohydrates and fat (expressed in equivalent of digestible carbohydrates) by the amount of digestible crude protein.

5. What is the nutritive ratio of oat straw?

SOLUTION:

100 pounds of oat straw contain 1.0 pound of digestible crude protein, 42.6 pounds of digestible carbohydrates and 0.9 pound of digestible fat.

Fat	Heat equiv.	Diges. carb.	Diges. crude protein

$[(0.9 \times 2.25) + 42.6] \div 1.0 = 44.6$ (The second factor of the ratio.)

Liges. carb. equiv.

The nutritive ratio of oat straw is, therefore, 1 to 44.6; or it may be expressed as $1 : 44.6$ or $\frac{1}{44.6}$, which means one pound of digestible crude protein to 44.6 pounds of combined digestible carbohydrates and fat.

*One hundred pounds is taken when the amount of feed is not expressed; otherwise the total amount of digestible nutrients is determined from the amount of feed fed.

**Digestible carbohydrates* includes digestible nitrogen-free extract and digestible crude fiber combined.

6. Determine the nutritive ratio of oats.

7. What is the nutritive ratio of crimson clover hay?

8. Compare the nutritive ratio of soy beans with that of shelled dent corn.

Which contains the more digestible crude protein in proportion to combined digestible carbohydrates and fat?

A feed or ration is said to have a *narrow* nutritive ratio when it contains much digestible crude protein in proportion to combined carbohydrates and fat; and a *wide* nutritive ratio when it contains a small amount of protein to carbohydrates and fats. The second factor in a narrow nutritive ratio, therefore, is a small number; in a wide nutritive ratio it is a comparatively large number.

9. Which has the narrower nutritive ratio, shelled corn or gluten meal?

10. What is the nutritive ratio of wheat bran? Is it wide or narrow? Compare this nutritive ratio with that of alfalfa hay.

(a) Determine the nutritive ratio of the following ration fed to a lot of range lambs at the Oklahoma Experiment Station* with as good results as compared with an alfalfa ration. (The lambs were being fattened and were given all they could consume.)

Cowpea hay 1.5 pounds
Cornmeal 1.6 pounds

SOLUTION:

Step 1. Table on page 247 shows cowpea hay to contain digestible nutrients as follows,—13.1% of protein, 33.7% of carbohydrates, 1.0% of fat. Cornmeal contains 6.9% of protein, 69.0% of carbohydrates, 3.5% of fat.

Step 2.

$1.5 \times .131 = 0.196$ lb. digestible proteins fed in the cowpea hay.

$1.5 \times .337 = 0.505$ lb. digestible carbohydrates fed in the cowpea hay.

*Oklahoma Bulletin 78.

1.5 × .01 = 0.015 lb. digestible fat fed in the cowpea hay.
1.6 × .069 = 0.11 lb. digestible protein fed in the cornmeal.
1.6 × .69 = 1.104 lbs. digestible carbohydrates fed in the cornmeal.
1.6 × .035 = 0.056 lb. digestible fat fed in the cornmeal.

Step 3.

[(0.015 + 0.056) × 2.25] + (0.505 + 1.104) = 1.77 lbs. (carbohydrates equivalent, or combined digestible carbohydrates and fat).
fat equivalent *carbohydrates*

Step 4.

1.77 ÷ (0.196 + 0.11) = 5.8 (second factor in nutritive ratio)
protein

The nutritive ratio of the above ration is, therefore, 1 to 5.8, or 1:5.8. Is this ratio wide or narrow?

11. A farmer fed the following fair ration to his dairy cows: 22 pounds of red clover hay; 8 pounds of ground dent corn.

(a) Determine the total digestible crude protein fed in this ration.

(b) How many pounds of digestible carbohydrates were fed daily to each cow?

(c) How many pounds of digestible fat were fed?

(d) What is the nutritive ratio of this ration?

12. Horses weighing 1,300 pounds at hard work were fed on an average daily ration consisting of:

16 pounds of timothy hay.
10 pounds of oats.
5 pounds of corn (cracked).
1 pound of oil meal (linseed meal).
1 pound of wheat bran.

(a) Tabulate the amount of each digestible nutrient fed daily in each feed.

(b) Determine the total amount of each of the digestible nutrients fed in this ration.

(c) What is the nutritive ratio of this ration?

13. According to Wolff feeding standards, horses weighing 1,300 pounds and at heavy work should receive

daily 34 pounds of dry matter*, 3.3 pounds of digestible crude protein, 17.7 pounds of digestible carbohydrates and 1.05 pounds of digestible fat. How does this feeding standard compare with what was fed in problem 12? The horses in problem 12 each lost 50 pounds in four weeks. Why?

(a) Would adding 3 pounds of alfalfa hay, 5 pounds of oats and 3 pounds of corn to the ration in problem 12 make it near a balanced ration?†

14. A dairy cow weighing 1,000 pounds and giving 22 pounds of milk daily should receive 29 pounds of dry matter*, 2.5 pounds of digestible crude protein, 13 pounds of digestible carbohydrates and 0.5 pound of digestible fat. (Wolff feeding standards.)

(a) What is the nutritive ratio of a ration satisfying these requirements?

(b) According to this standard, did the farmer in problem 11 feed a balanced ration—assuming his cows weighed 1,000 pounds and averaged 22 pounds of milk daily?

15. The following ration may be regarded as a good one for a dairy cow:

35 pounds of corn silage.
12 pounds of alfalfa hay.
3 pounds of ground corn.
1 pound of cottonseed meal.

(a) Tabulate the amount of each digestible nutrient in each of the feeds fed daily in this ration.

(b) How many pounds of roughage in this ration? How many pounds of concentrates?

*Dry matter is only an indication of the bulk of a feed or a ration.

†A balanced ration is the feed or combination of feeds furnishing the several nutrients in such proportion and amount as will properly and without excess of any nutrient nourish a given animal for 24 hours.—*Feeds and Feeding.*—HENRY & MORRISON.

(c) In actual practice this was regarded as a well-balanced ration for cows giving 30 pounds of milk daily testing 4% fat. Determine its nutritive ratio.

16. The Haecker standard (Minnesota) requires that a 1,000-pound cow should receive daily 0.7 pound crude protein, 7.0 pounds carbohydrates and 0.1 pound of fat (all digestible) to maintain her, independent of the milk she produces. For each pound of 4% milk produced daily there should be added 0.054 pound crude protein, 0.24 pound carbohydrates and 0.021 pound of fat (all digestible). (See page 236.)

(a) Determine the total amount of each nutrient (digestible), required to feed a 1,000-pound dairy cow giving 30 pounds of 4% milk daily according to this feeding standard.

(b) Determine the nutritive ratio of a ration satisfying these requirements.

(c) How nearly does the ration in problem 15 satisfy these requirements according to the Haecker standard, (a) from standpoint of nutrients required and (b) from standpoint of nutritive ratio?

17. A dairy cow is to be fed 30 pounds of corn silage and 8 pounds of red clover hay daily. She produces each day 30 pounds of milk testing 5% butter-fat. According to the Wisconsin Station rule, this cow should receive as many pounds of concentrates daily as she gives pounds of butter-fat in a week. Fill out this ration with gluten feed and ground corn mixed in proportion of 3 parts to 2 parts by weight respectively.

(a) How many pounds of each of these concentrates are required to satisfy this feeding rule and condition?

(b) Determine the nutritive ratio of this ration.

(c) Assuming this cow to weigh 1,000 pounds, what would the Haecker feeding standard require in digestible nutrients when to the maintenance requirement of the cow must be added daily 0.060 pound of digestible crude protein, 0.28 pound of digestible carbohydrates, and 0.024 pound of digestible fat for each pound of 5% milk produced? (See problem 16 or page 236 for Haecker's maintenance* requirement.)

(d) What should the nutritive ratio of the ration be according to the above Haecker standard?

18. A ration containing oats, 5 parts; corn, 4 parts; and wheat bran, 1 part, fed to yearling wethers gave excellent results as compared with other combinations tried. The average amount of grain consumed per head daily was 1.54 pounds.

Figure 9.—A Champion Pen of Berkshires. Courtesy of Wis. Live Stock Ass'n.

**Maintenance ration* is one that furnishes a sufficient amount of nutrients but no more than is required to maintain a given animal at rest, so that it will not gain or lose in weight.—*HENRY AND MORRISON, Feeds and Feeding.*

(a) Determine the amount of each concentrate fed per head daily.

(b) How many pounds of grain* were required to produce one pound of gain when the average weekly gain per head was 2.57 pounds?

(c) Determine the nutritive ratio of the grains fed.

19. The Wolff Feeding Standard for Fattening Swine. Requirement per day per 1,000 pounds live weight:

	Dry matter	Digestible Nutrients			
		Crude protein	Carbohydrates	Fat	Nutritive ratio
First period.....	36 lbs.	4.5 lbs.	25.0 lbs.	0.7 lb.	
Second period....	32 lbs.	4.0 lbs.	24.0 lbs.	0.5 lb.	
Third period.....	25 lbs.	2.7 lbs.	18.0 lbs.	0.4 lb.	

(a) Determine the nutritive ratio for each of the feeding periods. What do these nutritive ratios mean with reference to kinds of feed to be fed in each period?

(b) What kinds of feeds may be used to narrow up a ration or a nutritive ratio?

(c) What kinds of feeds will widen a ration or a nutritive ratio?

(d) Turn to table on page 247 and make out a list of feeds containing large amounts of protein. Another list containing those rich in carbohydrates.

(e) How much corn and barley would you feed a pig daily at the beginning of the fattening period (first period), when the pigs average 125 pounds? Compound a balanced ration.

*Grain—commonly used to mean concentrates.

SOLUTION:

Step 1. For each 1,000 lbs. of live weight, or to 8 pigs, must be fed daily 36 lbs. of dry matter, 4.5 lbs. of protein, 25 lbs. of carbohydrates, and .7 lb. of fat. (All digestible.)

Step 2.

20 lbs. of each grain will be taken for a trial.
$20 \times .895 = 17.9$ lbs. of dry matter in the dent corn.
$20 \times .075 = 1.5$ lbs. of protein in the dent corn.
$20 \times .907 = 18.1$ lbs. of dry matter in the barley.
$20 \times .09 = 1.8$ lbs. of protein in the barley.
$17.9 + 18.1 = 36.0$ lbs. of dry matter, which indicates enough bulk.
$1.5 + 1.8 = 3.3$ lbs. of protein. (Not enough.)

Step 3.

For second trial, 10 lbs. of corn, 30 lbs. of barley.

This combination supplies 36.2 lbs. of dry matter, 3.45 lbs. of protein, 26.8 lbs. of carbohydrates and .94 lb. of fat. (Not sufficient protein, though a trifle too much combined carbohydrates and fat.)

Step 4.

12 lbs. of corn, 25 lbs. of barley, and $2\frac{1}{2}$ lbs. of tankage meets the requirement very well, supplying 36 lbs. of dry matter, 4.55 lbs. of protein, 24.8 lbs. of carbohydrates, and 1.2 lbs. of fat, (all digestible).

Step 5.

Daily ration for one pig will be $\frac{1}{8}$ of these amounts, or $1\frac{1}{2}$ lbs. of corn (shelled), $3\frac{1}{8}$ lbs. of barley (ground or soaked before feeding), and about $\frac{3}{10}$ lb. of tankage.

20. Figure out a ration for fattening swine in the second period. As a trial, feed 1 part of wheat middlings to 2 parts corn. Approach as near the above Wolff feeding standard as possible.

(a) How much of each feed is required per 1,000 pounds of live weight daily?

(b) When the pigs average 145 pounds, how much of each feed is required per hog per day? Total per hog per day? Amount per hog at each feeding when fed 3 times per day?

(c) How many pounds of each feed are required for 50 pigs for 3 weeks? Total amount?

21. Compare the nutritive ratio of timothy and alfalfa hay. Which hay would balance up a corn and corn silage ration in feeding dairy cows?

22. Illinois Station concluded that in feeding dairy cows alfalfa hay was worth $10.86 per ton more than timothy. On this basis how much more are 6 acres of alfalfa worth than 6 acres of timothy when alfalfa yields on an average 1.6 tons per acre in each of 3 cuttings and timothy yields on an average 1½ tons and sells for $9.50 per ton?

23. Compare the nutritive ratio of the following two rations fed to dairy cows:

No. 1		*No. 2*	
Red clover hay	6 lbs.	Red clover hay	6 lbs.
Corn silage	30 lbs.	Corn silage	30 lbs.
Cornmeal	6 lbs.	Cornmeal	6 lbs.
Alfalfa	8 lbs.	Wheat bran	8 lbs.

(a) These cows averaged about 16 pounds of milk daily. Wolff feeding standards show that these cows should receive daily about 2 pounds crude protein, 11 pounds carbohydrates, 0.4 pound fat (all digestible). Compute the nutritive ratio of this standard and compare with the nutritive ratio of the two rations.

24. The results obtained from feeding the two rations in problem 23 showed that 8 pounds of alfalfa were equal to 8 pounds of wheat bran.

(a) On this basis, 12½ tons of alfalfa hay cocked up in a field is equivalent to how many piles of bran, each pile containing 40 pounds?

(b) What would be the value of each pile when wheat bran costs $25 per ton?

25. Work out a balanced ration for a cow on your farm, using feeds available, (a) according to the Wisconsin Station rule. (See page 105); (b) according to Wolff feeding standard. (See table on page 244); (c) according to Haecker feeding standard. (See table on page 236.)

Hints on Feeding:

1. It is impossible to formulate an iron-clad rule in feeding.

2. Food value and palatability of feeds and the individuality of the animal fed are important factors to consider in feeding.

3. The stockman can gain much help in feeding by studying feeding standards and scientific feeding tests.

CHAPTER V

THE DAIRY

The dairy cow is one of the most useful of our farm animals. When she is carefully studied and cared for she becomes a constant source of profit. The products of the dairy, milk, butter and cheese, form an important part of human food. The successful dairyman knows the business end of dairying so that he may be able to reduce milk to its equivalent of butter-fat*, butter and cheese, and to balance milk and its products over against dollars and cents.

ORAL PROBLEMS

1. A cow gives 35 pounds of milk per day. At this rate how much will she give in a month?

2. How many pounds of butter-fat in 125 pounds of milk testing 3% fat? Testing 5%?

3. How many pounds of butter-fat in 300 pounds of milk testing 4.5% butter-fat?

4. 8.2 pounds of butter-fat are contained in 200 pounds of milk. What is the test?

5. If 500 pounds of milk contain 19 pounds of butter-fat, what does the milk test?

6. Three fourths of a pound of butter-fat per day for an average for 300 days may be considered a good average yield for a dairy cow. How many pounds of fat does this amount to?

7. What is the average butter-fat production of the cows on your farm or in your neighborhood?

**Butter-fat*, milk-fat, is the fat of milk.

8. Colantha 4th's Johanna's seven-day record (Holstein) was 651.7 pounds of milk. What was the average per day?

9. A cow gives 200 pounds of milk in 10 days. How many quarts does she average daily? (For short, regard 25 pounds = 3 gallons.)

10. When it costs 21 cents to produce 1 pound of butter-fat in 4% milk, what does it cost per quart of milk?

11. $8\frac{3}{16}$ pounds of butter is how much more than $5\frac{1}{4}$ pounds?

12. Many dairy farmers aim to have all their mature cows produce a pound of butter-fat, on an average, for every day in the year. To do this a cow producing 4% milk must give on an average how many pounds of milk daily? How many quarts daily?

WRITTEN PROBLEMS

1. The number of dairy cows reported on the farms in the United States in the twelfth United States census, taken in 1900, was 17,135,633, which was 16.9% less than was reported in 1910. How many dairy cows reported in 1910?

2. The 1900 census reported 7,728,583,349 gallons of milk produced in the United States. How much did that average for every man, woman and child per year? Per day? (See page 227, problem 24(a).)

3. In 100 pounds of average milk are contained 87.1 pounds of water and 4.9 pounds of milk sugar.

(a) How many gallons of water are contained in 2,500 pounds of milk?

(b) How many pounds of milk sugar?

Figure 10.— The Original Babcock Tester. Courtesy of Wis. Exp. Sta.

4. According to actual tests, it costs on an average 15.8 cents to produce one pound of fat in Guernsey milk testing 5.2% butter-fat. Determine the cost per quart* of milk.

5. Other tests have shown that it costs on an average 21.5 cents per pound of fat in Holstein milk testing 3.43% butter-fat. Determine the cost on this basis to produce a quart of milk.

6. K. P. Pontiac Lass (Holstein) produced 585.5 pounds of milk in 7 days testing 6.03% butter-fat.

(a) How many pounds of butter-fat were produced?

(b) How many pounds of butter is that equivalent to according to the rule of the Holstein-Friesian Association; viz., pounds of butter-fat $\times 1\frac{1}{4}$ = pounds of butter?

(c) This estimated amount of butter contains what per cent of butter-fat?

7. May Rilma (Guernsey) produced 19,673 pounds of milk in 365 days testing on an average 5.45%.

(a) How many pounds of butter-fat were produced in that year?

(b) What was the average daily production of pounds of milk? Of butter-fat? Quarts of milk? (1,000 pounds of milk = 465 quarts.)

*One gallon of milk weighs 8.59 pounds.

(c) How many pounds of butter would the total amount of butter-fat be equivalent to according to the rule of the Association of American Agricultural Colleges; viz., pounds of butter-fat $\times 1\frac{1}{6}$ = pounds of butter?

(d) According to creamery experience 1 pound of butter-fat in milk produces 1.15 pounds of butter. At 35 cents per pound, determine the value of the butter produced by this cow in one year.

(e) How many average cows in your neighborhood are required to produce as much butter-fat in one day as was produced by May Rilma in one day?

8. When one pound of butter-fat in milk produces 1.15 pounds of butter, what per cent of butter-fat does that butter contain?

9. According to this rule, when 100 pounds of milk will produce 4 pounds of butter, what does the milk test? (Assuming no loss of butter-fat.)

10. A dairyman fed a ration consisting of 40 pounds of corn silage, 15 pounds of clover hay, 3 pounds of ground corn and one pound of cottonseed meal to his cows averaging 22 pounds of milk daily. When corn silage was worth \$3 per ton, clover hay \$10, ground corn \$1 per hundred and cottonseed meal \$30 per ton, what was the cost of feed per quart of milk?

11. A man sold 650 pounds of cream* and was credited with $227\frac{1}{2}$ pounds of butter-fat. What was the per cent of butter-fat in the cream sold, or what per cent cream did he sell?

**Cream* is that portion of milk rich in milk-fat which rises to the surface of milk on standing, or is separated from it by centrifugal force, and contains not less than 18% of milk-fat.

12. 850 pounds of 30% cream is equivalent to how many pounds of butter-fat?

(a) The butter-fat contained in 1,250 pounds of 4% milk is equivalent to how many pounds of 30% cream?

SOLUTION: $1250 \times .04 = 50$ lbs. fat in the milk. 50 lbs. of fat must be .3 or .30 of the amount of 30% cream, hence $50 \div .3 = 166\frac{2}{3}$ lbs. of 30% cream.

Proof: $166\frac{2}{3} \times .30 = 50$ lbs. of fat.

13. How many pounds of 30% cream may be taken from 500 pounds of milk testing 4.5% fat, assuming no loss of butter-fat in separating? (See page 114, footnote.)

14. How many pounds of 35% cream may be taken from 1,500 pounds of milk testing 5.6% fat, assuming $1\frac{1}{2}$ pounds of butter-fat is lost in separating?

(a) How many pounds of skim milk were drawn from the separator?

(b) Determine the per cent of fat in the skim milk.

15. 360 pounds of 25% cream were taken from how many pounds of milk testing 4% fat when 2 pounds of fat were lost in skimming?

(a) How many pounds of skim milk were obtained? What per cent fat did it contain?

16. At a small creamery 2,930 pounds of skim milk testing 0.05% fat were drawn from 3,500 pounds of whole milk received in one day. The cream obtained tested 25% fat and produced 166 pounds of butter.

(a) How many pounds of cream were obtained?

(b) What was the average test of the whole milk received?

(c) What was the per cent of overrun* in the butter?

**Overrun* in butter is the amount of water, casein and salt incorporated in the butter-fat in making butter. Per cent overrun is determined as follows:

[(*Pounds of butter made – pounds of butter-fat received*) ÷ pounds of butter-fat received] × 100 = per cent of overrun.

17. 5,460 pounds of milk testing on an average 3.6% butter-fat were taken in at a creamery as a daily average for one month. The average overrun in butter-making was 18.2%.

(a) How many pounds of butter were made during that month?

(b) When the farmers were paid on an average $1.20 per hundred for their milk; i. e., for the butter-fat contained in 100 pounds of milk, and 36 cents per pound was realized for the butter, what was the creameryman's net receipts?

18. 75 pounds of milk testing 4.8% fat were mixed with 160 pounds of skim milk testing 0.02% fat. Determine the per cent butter-fat in the resulting mixture.

19. A milk customer wanted 20 pounds of 25% cream. The milkman gave him a mixture of 5 pounds of 4% milk and 15 pounds of 30% cream. Did the milkman give his customer what he wanted?

20. It is desirable at times to standardize milk or cream by using milks or creams containing different amounts of butter-fat. The Pearson rule is the simplest to follow; viz., draw a rectangle with two diagonals as shown in Fig. 11, place the tests of the milks or creams to be mixed at the left hand corners (25% and 4%, Figure 11); in center place the per cent butter-fat desired in the mix-

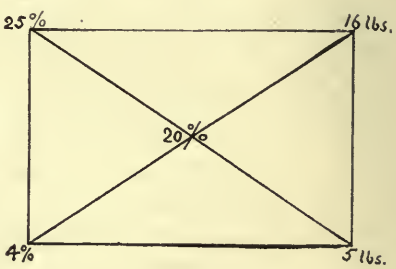

Figure 11.—The Pearson Method in Standardizing Milk or Cream.

ture (20%). At the right-hand corners place the differences between the two numbers in line with these corners. The number at the upper right-hand corner (16) represents the number of pounds of milk or cream to use containing the per cent butter-fat indicated in the upper left-hand corner; and the number at the lower right-hand corner (5) represents the number of pounds of milk or cream to use containing the per cent fat indicated in the lower left-hand corner.

(a) How many pounds each of 25% cream and 4% milk are required to make 20% cream?

(b) Prove the rule.

(c) When 8 pounds of 25% cream and 2.5 pounds of 4% milk are mixed what per cent cream is obtained?

(d) Suppose 8 pounds of 25% cream were mixed with 15 pounds 4% milk. Would the mixture be cream?

21. How many pounds each of 30% cream and 3.5% milk are required to make 18% cream? Prove your answer.

22. How many pounds each of 6.5% milk and 18% cream are required to make a mixture testing 12% fat?

23. How many pounds each of 3.5% and 6.3% milks are required to produce 5% milk?

(a) How many pounds of each milk would be required to make 100 pounds of 5% milk?

24. A dairyman had 20% cream and milk testing 3.8%. In what proportion must he mix his cream and milk to make 5% milk? How many pounds of each must he use to bottle 150 quarts of the 5% milk? (See footnote, page 113.)

25. How many pounds of milk testing 4.8% butter-fat are required to produce one pound of butter? (See problem 7 (d) page 114.)

26. A cow gives in one milking 29 pounds of milk testing 6% fat. How many pounds of 85% butter does that amount of milk represent? How many quarts of milk per pound of butter?

The approximate amount of cured cheddar* cheese that can be made from 100 pounds of milk may be determined as follows:

Yield of cured cheddar cheese = per cent of butter-fat in milk × 2.6.

27. A dairyman has a herd of 25 cows. The average daily yield per cow is 30 pounds of 4.2% milk.

(a) How many pounds of cured cheddar cheese may be made from the milk produced from this herd in 30 days?

(b) How many pounds of butter?

(c) What is the difference in value when cheese is worth 18 cents and butter 35 cents per pound? When cheese sells for 13 cents per pound and butter for 30 cents?

28. In one month a private creamery took in on an average 10,500 pounds of milk daily. The farmers took back home daily 8,752 pounds of skim milk testing 0.034% fat, and 1,315 pounds of buttermilk testing 0.304% butter-fat. The cream separated tested 25% fat.

(a) How many pounds of 25% cream were separated daily?

(b) What was the daily loss of butter-fat in the skim milk? In the buttermilk? The total loss? Total loss per month?

(c) How many pounds of fat were taken in at the creamery daily?

**Cheddar cheese* is the common American cheese, sometimes called American cheddar. It receives its name from Cheddar, England, a small town noted for its cheese.

(d) What was the average test of the milk received?

(e) How many pounds of butter-fat were churned into butter?

(f) How many pounds of butter were made daily when the butter produced contained 13.5% of water, 3% salt and 1% casein?

(g) What was the per cent of overrun in this butter? (See footnote on page 115.)

(h) During that month the owner of the creamery paid the farmers 35 cents for every pound of butter-fat taken in at the creamery, which was the same price he received per pound of butter. What was his net income from this creamery per day? Per month?

29. Suppose the above creamery, instead of taking in the whole milk, took in the amount of 25% cream daily as it was separated from the milk and made the same kind and amount of butter.

(a) Determine the per cent of overrun.

(b) Explain this difference.

(c) In which case would the owner of the factory likely receive the greater profits? Explain.

Summary of Facts:

State the important facts brought out in the preceding problems.

CHAPTER VI

THE SOIL

The soil, for the most part, is material resulting from the weathering of rocks, hence it is underlaid by rocks wherever it is found. This comparatively thin layer covering the earth as a soft blanket has supported myriads of plants and animals for millions of years. It is the foundation of all agriculture. A few facts and figures concerning its physical character should be of interest to us all.

PROBLEMS

1. How many square feet of soil in one acre?

2. An acre of dry, sandy soil 7 inches deep weighs in round numbers 2,500,000 pounds; a clay loam or silt loam about 2,000,000 pounds; a muck about 1,000,000; and a

Figure 12.—A Good Drainage Ditch. The first thing to do in reclaiming a marsh is to drain it. This ditch is deep enough to permit drain tile to empty into it. Courtesy of Wis. Agr'l Exp. Sta.

dry, raw peat 350,000 pounds. What is the weight of a cubic foot of dry sand? Of clay or silt loam? Of muck? Of peat?

3. An acre of dry, "heavy"* clay loam 10 inches deep weighs how many tons less than an acre 10 inches deep of a "light" sandy soil?

4. It took 107 cubic inches of water to saturate one gallon jar full of dry clay loam soil and 79 cubic inches to saturate the same volume of dry sand. What is the approximate per cent of pore space in the clay loam? In the sand?

5. It was found that a fine clay had 56% pore space, and a coarse sand 40%. What per cent of pore space has the clay compared with the sand?

6. An examination of a fine sandy loam showed that it consisted of 59.4 parts, by weight, of sand†; 33.2 parts of silt; and 7.4 parts of clay. How many ounces each of sand, silt and clay are contained in two pounds of this class of soil?

7. A sample of silt loam soil was found by a mechanical analysis to consist of 3.8 pounds of coarse and fine sand; 15.7 pounds of silt; and 5.5 pounds of clay. This class of soil consists of what per cent of sand? Of silt? Of clay?

8. How many soil particles (clay), each measuring 0.0005 of a millimeter in diameter, will be required to span one linear inch?

9. How many fewer particles would it require to span a linear inch if they were silt particles measuring .01 of a millimeter in diameter?

10. Weigh out an amount of dry soil equal in weight to a new nickel. Divide this amount of soil into five equal

*"Heavy" soil—a soil hard to work, like clay.
"Light" soil—a soil easy to work, like sand.

†Sand—the coarser soil particles.
Silt—the medium sized soil particles.
Clay—the finest of soil particles.

portions. Each portion weighs one gram. What part of an average thimbleful does one gram of dry soil make?

11. A scientist was able to estimate 70,500,000 soil bacteria in one gram of a rich garden soil, and only 50,000 in the same amount of poor soil. How many more bacteria were contained in the gram of rich soil? The rich soil contained how many times the number of bacteria found in the poor soil?

12. One gram of soil near the surface of a fertile field was found to contain 56,250,000 soil bacteria, and only 15,000 were found in the same quantity of soil taken 3 feet

Figure 13.—One Way of Breaking a Marsh. After drainage cultivation is the next step in reclaiming a marsh. The wild sod must be subdued and the deficient mineral elements supplied. Courtesy of Wis. Exp. Sta.

below the surface. What per cent of bacteria is in the surface soil compared with that which is found in the subsoil?

13. The total amount of surface area of the soil particles in one pound of coarse sand, the particles of which measure one millimeter in diameter, is estimated at 11 square

feet. How many square rods of surface are contained in one pound of fine clay when the particles measure .001 of a millimeter in diameter?

14. $7\frac{1}{2}$ pounds of water were slowly poured over each of four 6-pound samples of dry soil — sand, clay, loam, muck (marsh soil) and a mixture of equal parts of sand and peat. All samples were held in funnels having cloth strainers at the bottoms. $6\frac{1}{5}$ pounds of water were caught as drippings from the sand; 4 pounds, 12.8 ounces, from the clay loam; two drops from the muck; and 5.3 pounds from the mixture of sand and peat. Express in per cent of the dry weight of soil the water-holding capacity of each kind of soil used.

A Few Facts Worth Remembering:

1. A "light" soil is by weight the heaviest soil.

2. A "heavy" soil is more porous than sand.

3. The amount of sand, silt and clay a soil contains determines its class name; i. e., sand, silt loam, clay loam, etc.

4. Most soils teem with bacteria and other organisms.

5. Sand has the lowest water-holding capacity of any soil.

6. Adding organic matter and thus increasing the humus in a soil increases its water-holding capacity. How was this shown?

CHAPTER VII

WHAT CROPS REQUIRE

At first thought it is hard to perceive the fact that growing crops require other things besides water, sunlight and air. Indeed, it was thought at one time that a tree was nothing more than water that had undergone a mysterious change in the soil. Scientists have demonstrated that plants also require *nitrogen*, *phosphorus*, *potassium*, *calcium*, *magnesium* and other elements.

ORAL PROBLEMS

1. A cubic foot of sand weighed 110 pounds. What is the weight of 432 cubic inches of that sand?

2. A cubic foot of dry, heavy clay soil was found to weigh 75 pounds. What is the weight of 216 cubic inches of that soil?

3. Approximately $\frac{4}{5}$, by weight, of the atmosphere is nitrogen gas. A column of atmosphere with base one inch square contains how many pounds of this element?

4. King found that it requires 576.5 pounds of water to produce one pound of dry matter in clover. How much water was required to produce 15 pounds of green clover containing 60% water?

5. King further found that it requires 464 pounds of water to produce 1 pound of dry matter in barley. How many pounds of water were removed from the soil when 22 bushels of barley were raised, representing 2,000 pounds of dry matter? How many tons? How many gallons?*

*1 cubic foot of water = 62½ pounds approximately.

6. A 65-bushel corn crop per acre removes from the soil about 18.06 pounds of phosphorus. How many pounds of this element would be removed from the soil by 9 acres of such corn?

7. One ton of alfalfa hay contains 4.7 pounds of phosphorus. How many pounds of phosphorus are removed from the soil by 8 acres, averaging 5 tons per acre?

8. One ton of sugar beets contains, on an average, 5.2 pounds of nitrogen, 0.7 pound of phosphorus and 5.3 pounds of potassium. How many pounds of each of these elements are lost from the soil when 15 tons of sugar beets are sold?

Figure 14.—Preparing a Seed Bed. Good plowing is an accomplishment not only to be proud of, but which has its reward in better crops.
Courtesy of Wis. Exp. Sta.

WRITTEN PROBLEMS

1. All plants take carbon from the air through their leaves in the form of carbon dioxide gas. 45% of the corn kernel is carbon. How many pounds of carbon in 20 bushels of shelled corn?

(a) How many pounds of soft coal will this amount of carbon be equivalent to when soft coal is about $\frac{9}{10}$ carbon?

2. King found that it requires, on an average, 271 pounds of water to produce one pound of dry matter in corn. How many acre inches* of water are necessary to produce a 75-bushel crop of dent corn?

(a) Good corn will produce $1\frac{1}{3}$ times as much field-cured stover† as ear corn. How many tons of stover are produced per acre in growing this 75-bushel corn crop?

(b) Very dry stover contains, on an average, 9.4% moisture, dent corn 10.5%, and cobs 10% moisture. How many pounds of dry matter will be produced in this crop?

(c) How many tons of water does it require to cover one acre one inch deep?

(d) How many acre inches‡ of water are necessary to grow the 75-bushel corn crop? What is the average amount of rainfall in your section or state? Is all this rainfall used by crops?

(e) How many square rods are required to produce one bushel of this corn? Measure off this area.

(f) How many barrels of water must be furnished by the soil on this area of land to produce one bushel of corn?

3. According to King it requires 504 pounds of water to produce one pound of dry matter in the oat crop. How many inches of water are required to produce a 50-bushel oat crop

*Follow steps in problems a, b, c, d.

†Stover—corn stalk with ears removed.

‡An acre inch of water is that amount of water required to cover an acre one inch deep.

when the ratio of straw to grain is 3 to 1? (Consult table on page 247 for dry matter.)

4. A silt loam 21 inches deep underlaid by coarse gravel was found to contain 22% of water in the spring. (Per cent based on dry weight of soil.) A good catch of red clover was secured on this land the previous year. It requires 576 pounds of water to produce one pound of dry matter in clover. Assuming that 8.4% of the moisture in the soil cannot be used by the clover, how many inches of rainfall will be necessary to produce a two-ton hay crop, assuming further that 40% of the rainfall is lost in surface runoff and leaching?

5. How much water will be supplied by the gravelly subsoil in the previous problem?

6. Two fields were lying side by side. A crop of oats was just threshed from one, and the other, which was well cultivated, was growing a fine crop of corn. It was found that the soil in the cultivated field eight inches deep contained 15.3% of moisture, or 70% more than in the other field. What per cent of moisture was contained in the soil in the stubble field? Explain this difference.

7. The average annual rainfall of some parts of the dry-farm territory in the United States is 15 inches, or 61.4% less than that of Ohio. What is the average annual rainfall of Ohio?

8. A farmer raised 30 acres of corn averaging 65 bushels of shelled corn per acre, and 24 acres of timothy hay yielding $1\frac{1}{2}$ tons per acre. How many pounds of nitrogen were removed from his soil by these crops? (See page 240.)

9. How many pounds of phosphorus were removed from the soil by the crops in problem 8? How many pounds of potassium? (See page 240.)

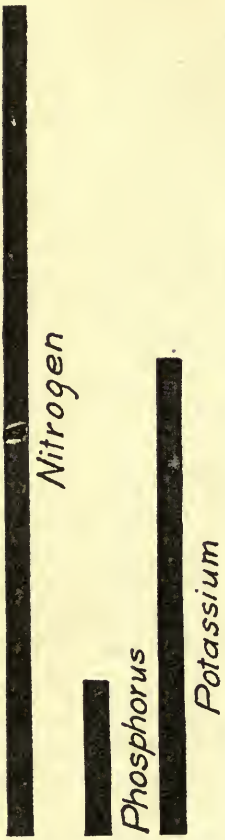

Figure 15.—Plant-Food Elements Removed by a 75-bushel Corn Crop. 109.5 lbs. nitrogen, 20.8 lbs. phosphorus, and 63 lbs. potassium.

10. What per cent of the total amount of potassium taken from the soil by a 15-bushel flax crop and a 30-bushel wheat crop is contained in the stalks and straw?

11. In Figure 15 determine the number of pounds of plant-food elements represented by each $\frac{1}{4}$ inch of the heavy lines.

12. By a similar diagram as shown in Figure 15 show the comparative amounts of nitrogen, phosphorus, and potassium removed from one acre by a 1,500-pound tobacco crop. (Use the same scale.)

(a) A man sold his oats from 20 acres which averaged 60 bushels per acre. What fractional part of the total amount of phosphorus taken from the soil by the oat crop did he sell?

SOLUTION:

Step 1.

A 50-bushel oat crop removes approximately 8 lbs. of phosphorus in straw and grain. (Table, page 240.)

A 60-bushel crop will remove approximately $\frac{1}{5}$ as much more, or 9.6 lbs. per acre.

$9.6 \times 20 = 192$ lbs. phosphorus removed from the soil by 20 acres of 60-bushel oat crop.

Step 2.

68.7% of the phosphorus in the total oat crop (grain and straw) is contained in the grain (table, page 240); hence the amount of phosphorus the man sold in his grain would be $196 \times 68.7\%$, or 132 lbs.

132 lbs. is $\frac{11}{16}$ of 192, the total amount of phosphorus removed by his oat crop.

The man sold, therefore, $\frac{11}{16}$ of the total amount of phosphorus taken from the soil by his 60-bushel oat crop.

13. A grain farmer sold his entire 20-acre flax crop yielding 15 bushels per acre and 50 acres of wheat averaging 18 bushels per acre. The straw of each crop was returned to the soil. What per cent of the total amount of phosphorus removed from the soil by these crops did he sell?

14. It is difficult to determine how much nitrogen leguminous plants, like clover, alfalfa, etc., take from the soil reserve and how much is secured from the air indirectly through organisms in nodules on their roots. From some experiments, however, it is reasonable to assume, under average normal conditions, that about $\frac{1}{3}$ of the total amount of nitrogen contained in the clover and alfalfa plants (roots and all) is taken from the soil reserve. The rest is taken from the air through the organisms in the root nodules. A third of this total amount of nitrogen is left in the soil in the roots and stubble when the crop is cut for hay. The nitrogen contained in the hay, therefore, may be regarded as the amount "fixed" or taken from the air by the organisms in the nodules; and what is left in the roots and stubble will offset the amount taken from the soil reserve. Raising clover and cutting it for hay, therefore, does not increase the nitrogen content of the soil growing the clover.

(a) When the nitrogen content of the clover crop (roots and all) is equal to 120 pounds per acre, how many pounds are contained in the roots and stubble? In the portion cut for hay? How many pounds of nitrogen were taken from the soil reserve? From the air by means of organisms?

15. "A" thought he could enrich a 10-acre field of silt loam soil he owned by just growing red clover. The following year, being a favorable year, he cut $1\frac{3}{4}$ tons of hay per acre. He sold the entire crop. Was his soil enriched or further depleted in phosphorus, potassium and calcium, and how much?

16. Is it likely that Mr. "A" in problem 15 increased the nitrogen content of his soil by his method? How many pounds of nitrogen did he sell? What may this amount of nitrogen sold represent with respect to the quantity of nitrogen "fixed," or taken from the air by the clover crop?

(a) At 15 cents per pound what was the value of the nitrogen sold?

(b) If the clover crop were plowed under as a green manuring crop, each acre would have been enriched by how many pounds of nitrogen?

17. How much nitrogen, phosphorus and potassium are removed per acre by a 25-ton cabbage crop, a 200-bushel potato crop and a 15-ton sugar beet crop, in a three-year rotation? (See table, page 240.)

18. Determine the amount of phosphorus removed from one acre by a 2-ton red clover crop, a 15-bushel wheat crop and a 30-bushel pea crop, in a three-year rotation.

19. Compare the amount of calcium removed from the soil by 6 acres of alfalfa, averaging 5 tons of hay per acre per season, and 12 acres of medium red clover, averaging 2 tons per acre, with that removed by 25 acres of corn, averaging 50 bushels of shelled corn per acre, and 20 acres of oats, averaging 40 bushels per acre.

20. A field was cropped 60 years, as follows: 30 crops of wheat, averaging 15 bushels per acre; 20 crops of oats,

averaging 30 bushels per acre; 5 crops of corn, averaging 40 bushels per acre; and 5 crops of red clover, averaging $1\frac{1}{2}$ tons per acre.

(a) How many pounds of phosphorus and potassium were removed per acre during these 60 years of cropping? How many pounds of nitrogen?

Figure 16.—A Field of Harvested Grain. The soil has given up a part of itself in producing this crop. All crops remove fertility from the soil.

Important Truths:

1. Water is of the greatest importance to plants. It is used by them in tremendous amounts; hence soil moisture and rainfall should be conserved for use by growing crops.

2. All crops take nitrogen and mineral elements from the soil.

3. Most of the phosphorus required by plants is stored in the seeds, or grain; and most of the potassium used is found in the straw and stalks.

CHAPTER VIII

THE SOIL A GREAT STOREHOUSE

The soil not only affords a firm support for the aërial portion of plants, but it also supplies them with substances necessary for growth and development. The great work of plants is to manufacture these raw materials absorbed into food for animals. Thus the nitrogen, phosphorus, potassium, calcium and other mineral elements of our bodies come from the soil either directly or indirectly by way of plants. It is interesting to study the supply of plant food material stored in the soil and how this reserve may be used.

ORAL PROBLEMS

1. It is estimated that 780 out of 1,000 parts of a fertile clay loam soil is material incapable of supporting plant life. What per cent of this soil is of no use to the plant in supplying it with food elements?

2. A soil analyzed 2% potassium. Express this per cent in the decimal form. In the fractional form.

3. A soil analyzed 0.2% nitrogen. What fractional part of the weight of this soil is nitrogen? What decimal is this equivalent to?

4. A soil contains $\frac{1}{10}$ of one per cent of phosphorus. What fractional part of the weight of the soil is this? Express this in decimal form.

5. 0.21% nitrogen is what fractional part of a soil? Express decimally.

6. 0.3% potassium is what fractional part of a marsh soil? Express decimally.

7. Five tenths of one per cent of potassium is what fractional part of a muck soil?

8. A soil analyzed 0.25% nitrogen, 0.11% phosphorus and two and five tenths per cent potassium. What fractional part of this soil is nitrogen? Phosphorus? Potassium?

9. 0.02 per cent of phosphorus is what fractional part of the weight of a poor sand? What is the decimal form of this per cent?

10. Five hundredths of one per cent of nitrogen is what fractional part of a poor sand? What is the decimal form of this per cent?

WRITTEN PROBLEMS

1. Some barren soils in Maryland contain 0.009% of phosphorus. How many pounds of this element are contained in one acre 7 inches deep weighing 2 million pounds?

2. Compare this amount of phosphorus with that contained in a rich alluvial soil in Holland which analyzes 0.205 per cent of this element. (Use the same weight of soil per acre, 7 inches.)

3. A soil was found to contain 2,000 pounds of nitrogen, 300 pounds of phosphorus and 12,000 pounds of potassium in 2 million pounds of soil. What per cent of each of these elements was contained in that soil?

4. A soil in Manitoba, Canada, contains 20,100 pounds of nitrogen, 2,530 pounds of phosphorus and 17,100 pounds of potassium in 2 million pounds of dry soil. Express the amount of each of these elements in per cent of the weight of soil.

A great many soil surveys and analyses are now being made by the several states and the Federal government. Analyses stating the per cents of the important elements found in the soils mean but little to the average person if he has no standard for comparison. The fol-

lowing little table based on many analyses will help the student to judge soils of similar classes when only the chemical analyses are given. These figures may be used as basis for comparison.

Soil	*Nitrogen*	*Phosphorus*	*Potassium*
A fertile clay loam or silt loam	0.25 per cent	0.1 per cent	2.0 per cent
A poor sand	0.08 per cent	0.02 per cent	0.5 per cent
An average peat	3.00 per cent	0.12 per cent	0.3 per cent

5. What may be regarded as the standard amount in pounds per acre 7 inches deep, of nitrogen, phosphorus and potassium in a fertile clay loam or silt loam? (See page 120.)

6. Construct a table similar to the one above and determine the actual number of pounds of each of the elements in each of the three soils per acre 7 inches. (Assume weights of soils as given on page 120.) Do all soils contain the same amount of each of the different plant-food elements?

Figure 17.—A Greenhouse Fertilizer Test. This is one of the ways in which the needs of a soil are determined. This soil needs phosphorus. N stands for nitrogen, P for phosphorus and K for potassium.
Courtesy of Wis. Exp. Sta.

7. In comparing the per cents in the table above, what is the ratio of the nitrogen in the peat and that in the fertile clay or silt loam? What per cent is this ratio equivalent to?

8. In comparing the actual number of pounds in an acre seven inches deep, what is the ratio of the nitrogen in the peat and that in the clay loam? What per cent?

9. In buying land, which is safer to consider, the per cent or the actual number of pounds per acre seven inches of the plant-food elements in soils? Explain.

10. A cropped and unproductive silt loam was analyzed and found to contain 0.13% nitrogen and 0.043% phosphorus. How many pounds of each of these elements must be supplied to this soil per acre to equal that contained in the fertile silt loam given in table above?

Soils Are Not Inexhaustible:

A few scientists believe that soils are inexhaustible and are able to produce crops for untold ages to come. It must be remembered that every crop removed from the land reduces the fertility of the soil. The stern reality is that soils do "wear" out and fail to produce the profitable crops that they once did.

11. How many 50-bushel oat crops can be supplied by the amount of nitrogen contained in an acre 7 inches of sand which analyzes 0.091 per cent nitrogen?

Figure 18.—Making Corn Grow by Supplying Deficient Plant-Food Elements. For two years corn refused to grow on this marsh even though well drained. This shows how the trouble was analyzed.
Courtesy of Wis. Exp. Sta.

12. Eleven crops of corn from one acre, averaging 65 bushels of shelled corn, removes as much potassium from the soil as is contained in one acre of a certain peat soil $\frac{2}{3}$ of a foot deep. What is the per cent of potassium in this peat?

13. A rich silt loam weighing 2,100,000 pounds per acre eight inches (dry weight) contains 0.12% phosphorus. How many cotton crops averaging 500 pounds of lint per acre will the phosphorus in this soil supply?

14. A soil in Wisconsin was cropped 60 years, largely to wheat during the first 10 or 12 years; then to corn and oats and some clover. The land is now in a depleted condition and contains only 0.061% phosphorus. The virgin soil analyzes 0.123% phosphorus. What was the average annual loss of this element per acre seven inches deep? Assume soil weight to be 2 million pounds.

Important Truths:

1. Only a small part of a soil is capable of supplying crops with plant food elements.

2. The most important elements—nitrogen and phosphorus—are contained in the soil only in small amounts.

3. Every crop harvested reduces the amount of the plant food elements in the soil.

4. The amount of one, two or three of the important elements in some soils has been reduced to such an extent by continuous cropping that these soils are no longer regarded as productive.

CHAPTER IX

THE BALANCE SHEET OF SOIL FERTILITY

A good business man keeps a strict account of all transactions he makes with losses and gains. This is the only way he knows for a certainty whether or not he is contracting debt or reaping a profit. Every farmer should have some idea as to what the gain or loss may be in the fertility of his soil brought about by his method of farming. A balance sheet of soil fertility worked out by the following plan will give a fair idea of the approximate exchange of fertility on an average farm under average normal soil conditions, when the manure produced is given the best of care and all straw and other material like uneaten shredded corn stalks are used for bedding.

1. The amount of nitrogen, phosphorus and potassium contained in any crop sold, except the nitrogen in legumes* sold, to be considered lost to the soil. (Consult table, page 247, for fertility contained in crops and feeds.)

2. When manure produced is well cared for, losses† sustained when feeds are fed may be reasonably considered as follows:

(a) Nitrogen about 40 per cent loss.

(b) Phosphorus about 20 per cent loss.

(c) Potassium about 20 per cent loss.

3. The fertility elements in feeds purchased minus the loss in feeding to be regarded as gain to the soil.

*See explanatory note page 129 prob. 14.

†Loss of fertility in the feeding transaction includes the amount of the fertility elements retained by the animals and the unavoidable loss in handling the manure.

4. The nitrogen in clover and alfalfa hay fed on the farm minus the loss in feeding to be regarded as gain to the soil.

5. The nitrogen in clover and alfalfa hay sold to be regarded neither loss nor gain to the soil.

ORAL PROBLEMS

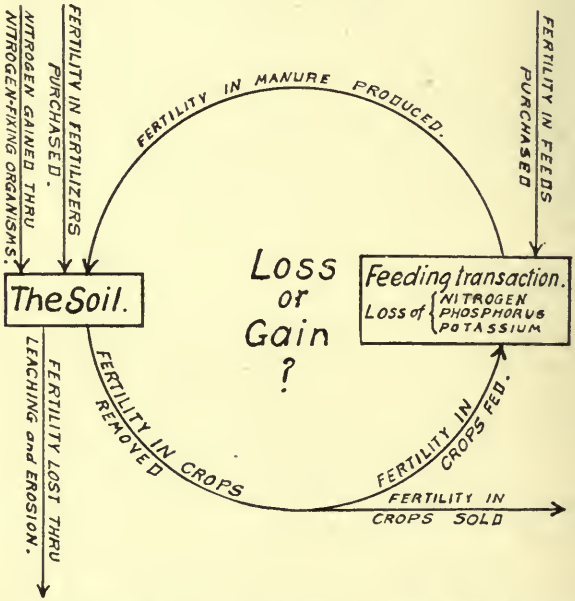

Figure 19.—Exchange of Fertility in Farming. Diagram showing how the soil may gain or lose in fertility. Assuming good care given the manure produced, the loss of fertility, when the feeds are fed, is about 40% of the nitrogen, 20% of the phosphorus, and 20% of the potassium.

1. In 1,000 pounds of oats (grain) are contained 19.8 pounds of nitrogen, 3.5 pounds of phosphorus and 4.6 pounds of potassium. How many pounds of each element are lost to the soil when 3 tons of grain are sold?

2. One ton of alfalfa contains on an average 4.7 pounds of phosphorus and 37 pounds of potassium. How many pounds of each of these elements are lost to the soil when 7 tons of alfalfa hay are sold off the farm? Any nitrogen lost from the soil?

3. A man raised and fed 1,000 pounds of oats (grain). How many pounds of nitrogen, phosphorus and potassium were lost in the feeding transaction? How many pounds regained in the manure?

4. Suppose the 1,000 pounds of oats were purchased and fed. Determine the amount of nitrogen, phosphorus and potassium gained through this transaction.

5. In 1,000 pounds of wheat bran are contained 25.6 pounds of nitrogen, 12.8 pounds of phosphorus, and 13.4 pounds of potassium. When 5 tons are fed what is the approximate gain of the fertility elements?

6. A farmer raised and fed 10 tons of red clover hay. When 1,000 pounds of hay contain 20.5 pounds of nitrogen and 1.7 pounds of phosphorus, determine the amount of phosphorus lost from the soil, assuming all manure is well cared for and returned to the soil. How many pounds of nitrogen gained?

WRITTEN PROBLEMS

1. A dairyman purchased 20 tons of red clover hay. This he fed to his stock. All manure produced was hauled directly to the fields.

   (a) Determine the amount of nitrogen, phosphorus and potassium purchased in the hay. (See table, page 247.)

   (b) Determine the amount of each of these fertility elements lost in the feeding transaction.

(c) Determine the amount of each of these elements added to the soil on his farm through this transaction.

2. Determine the amount of each of the fertility elements lost from the soil on the farm from which the 20 tons of clover hay were purchased.

3. A man exchanged 12 tons of timothy hay for 8 tons of wheat bran which he fed to his stock. Did the soil on his farm gain or lose in nitrogen, phosphorus and potassium, and how much? Assume good care given to the manure produced.

4. A small land-holder had 2 five-acre fields. One produced seven and one half tons of red clover hay and the other was kept in pasture. The hay was all fed without grain and all the manure produced from feeding this hay was hauled directly to the pasture field.

(a) How many pounds each of nitrogen and phosphorus were taken from the soil in the clover field? (See page 129, problem 14.)

(b) How many pounds of each of these two elements were added to the pasture field in the form of manure which was produced from feeding the clover hay?

(c) Determine the gain or loss of nitrogen and phosphorus to the soil in the clover field if all the manure were applied to that field instead.

(d) If the entire clover crop were plowed under, what would the balance sheet of fertility for that clover field show regarding the gain or loss of nitrogen and phosphorus? (See page 129.)

5. Ten tons of corn silage, 5 tons of red clover hay and 100 bushels of oats were fed mixed stock. The manure produced was well cared for.

(a) Determine the amount of nitrogen, phosphorus and potassium contained in the feeds fed.

(b) About how many pounds of each of these three elements would the manure produced from feeding these feeds contain?

(c) About what per cent of the fertility contained in these feeds may be recovered in the manure? (Assume that losses occur as given on page 137.)

6. A man had 30 acres of good pasture and pastured it to cows and some young stock. Assuming that each acre yielded as much green feed as is equivalent to $1\frac{1}{4}$ tons of mixed grass hay, and that 30 per cent of the nitrogen and 20 per cent of the phosphorus in the grass eaten is retained by the animals, determine the total loss of nitrogen and phosphorus to the soil in that field.

7. A farm produces annually 20 acres of alfalfa averaging 5 tons of hay per acre per season, and 30 acres of red clover averaging 2 tons of hay per acre. All the hay is fed on the farm, and all manure produced is well cared for. The soil on this farm is enriched by how many pounds of nitrogen annually through the growing and feeding of the alfalfa and clover?

(a) How many pounds of phosphorus are lost annually from the soil on the farm through this feeding transaction?

8. A farmer purchased 10 tons of cottonseed meal and 5 tons of oil meal (linseed meal).

(a) In the feeding of these feeds, how many pounds of nitrogen and phosphorus would be lost, assuming a 40% loss of nitrogen and 20% loss of phosphorus?

(b) If the manure were well cared for, what would be the gain of nitrogen and phosphorus to the soil through this purchase and feeding transaction?

9. About how many tons of wheat bran or cottonseed meal must be fed during the time that 15 tons of alfalfa hay and 40 tons of corn silage are fed in order that the total phosphorus content of the manure produced may be equal to that contained in the hay and silage fed?

10. A successful dairyman possessing a farm of 80 acres raises on the average the following crops:

Crops	*Acres*	*Average Yield per Acre*
Corn	10	20 tons silage.
Oats	28	75 bushels.
Hay (clover)	10	4 tons (2 cuttings).
Pasture	30	Equivalent to $1\frac{1}{4}$ tons of mixed grass hay.

He sells all the oats except 300 bushels which he feeds. All other crops are fed on the farm, and all straw is used for bedding. All corn is made into silage.

He buys and feeds each year 20 tons of wheat bran and 10 tons of gluten feed.

All manure is hauled directly to the field when possible. All milk is sold*.

(a) Determine the gain or loss of nitrogen in the soil on this farm by use of a balance sheet like the one below. Assume nitrogen loss on pasture to be 30%.

*When skim milk is fed on the farm the fertility in the milk fed regained in the manure should be regarded as gain.

Nitrogen Balance Sheet

Crops and Feeds	Loss of nitrogen in feeding (clover excepted)	Loss of nitrogen in sale of crops	Nitrogen gained through feeding clover and purchased feeds
Oats,—grain.....			
Corn,—silage.....			
Hay, (red clover)....			
Pasture.....			
Wheat bran.....			
Gluten feed.....			
Total.....			
Total loss and gain...			
Loss or gain.....			

It is safe to assume that very little or no fertility is lost from the straw used for bedding.

Fertility lost through leaching from the soil and washing is not taken into account.

(b) Construct a "Phosphorus Balance Sheet" and determine the loss or gain of phosphorus to the soil on this farm,—as follows:

Phosphorus Balance Sheet

Crops and Feeds	Loss of phosphorus in feeding	Loss of phosphorus in sale of crops	Phosphorus gained through purchased feeds
Oats,—grain.....			
Corn silage.....			
Hay,—clover.....			
Pasture*.....			
Wheat bran.....			
Gluten feed.....			
Total.....			
Total loss and gain...			
Loss or gain.....			

N. B. Assume no loss of phosphorus from the straw used for bedding.

*Assume 20% loss of phosphorus.

(c) If no feeds were purchased and no oats sold, but fed, what would the records show regarding the loss and gain of nitrogen and phosphorus? How many pounds of rock phosphate analyzing 13% phosphorus must be mixed with the manure to offset this loss of phosphorus?

(d) Suppose all the crops raised were fed and half the amount of each kind of feed purchased; determine the loss or gain of nitrogen and phosphorus.

(e) Determine the loss or gain of potassium on this dairy farm in a similar manner.

(f) Suppose this dairyman took poor care of the manure produced and allowed it to accumulate in the barnyard, thus subjecting it to heavy losses through leaching. Assuming under such conditions that the total loss of fertility in the feeding transaction to be 60% for nitrogen, 37% for phosphorus and 60% for potassium, determine the annual gain or loss of nitrogen, phosphorus and potassium to or from the soil on his farm.

11. Assuming good care given all manure produced, determine the approximate loss or gain of nitrogen and phosphorus to the soil on a farm when the following feeds were raised and fed on the farm: 100 tons of corn silage, 45 tons of red clover hay, 15 tons of timothy hay, 4 tons of oat straw, 300 bushels of corn, 333 tons of stover (shredded—$\frac{2}{3}$ of which was used for bedding and absorbent), 1,000 bushels of oats and 30 acres of pasture* equivalent to $\frac{3}{4}$ of a ton of mixed grass hay per acre.

Feeds purchased, 5 tons wheat bran, 3 tons tankage.

*Assume 30% loss of nitrogen and 20% loss of phosphorus in pasturing.

Crops sold, 100 tons of cabbage.

Eight acres of red clover (second growth equivalent to $\frac{3}{4}$ of a ton of hay per acre) were plowed under.

12. Make out a phosphorus balance sheet for a farm with which you are familiar.

Fertility Truths:

1. Grain farming without the use of fertilizers and legumes reduces the fertility of the soil most rapidly.

2. Even on a good dairy farm where no feeds or fertilizers are purchased, the phosphorus supply of the soil is reduced year by year.

3. The nitrogen supply may be maintained and increased through the growing and feeding of a good acreage of clover, alfalfa and other legumes.

4. To establish permanent agriculture, at least as much fertility should be returned to the soil as is removed by crops.

CHAPTER X

MANURE AND COMMERCIAL FERTILIZERS

Manure may be defined as a natural substance possessing a direct fertilizing value. The liquid excrement from farm animals contains nearly half of the nitrogen and potassium voided by them and should be carefully preserved. Open barnyard manure is about half as valuable as stall manure. A fertilizer may be defined as a substance which simply supplies one or other of the elements necessary for plant growth, as sodium nitrate, rock phosphate, etc. Commercial fertilizers may be grouped as follows: nitrogen or nitrate; phosphorus or phosphate; potassium or potash; and mixed or complete fertilizers.

MANURE

ORAL PROBLEMS

1. For practical purposes one is sufficiently accurate in estimating one ton average, mixed barnyard manure to contain approximately 0.5% nitrogen, 0.1% phosphorus and 0.4% potassium. How many pounds of each element are contained in one ton?

2. What is the value of the fertility contained in one ton of mixed manure when the nitrogen is worth 15 cents per pound, phosphorus, 10 cents, and potassium, 6 cents per pound?

3. Under average conditions, when straw is used for bedding, it requires about 25 cows to produce one ton of barnyard manure per day during winter or indoor feeding. At this rate about how many tons will 5 cows produce in one month?

4. About one ton of manure ready for field application (including bedding) is produced in one day by 50 average working horses. (Amount produced when horses are at work excluded.) How much manure will be produced by 5 horses in 10 days?

5. An average 1,300-pound horse will produce approximately 65 pounds of manure per day (including bedding), when kept in the barn most of the time. About how much manure will be produced by 3 such horses in 3 months?

6. Ten 480-pound steers in a fattening pen produced approximately $\frac{1}{4}$ of a ton of manure per day (bedding included). At this rate how much would be produced by 20 such steers in 20 days?

7. A 150-pound pig produces about 9 pounds of manure per day. At this rate now many pigs are required to produce one ton in one day?

8. 500 65-pound lambs in a feeding pen; during the first period, produced about one ton of yard manure daily. How much would have been produced by 3,000 lambs in 3 weeks?

9. A man keeps 5 horses and feeds 12 cows. About how much barnyard manure is produced on his farm during 7 winter months?

10. A man applies 8 tons of manure per acre. About how many acres can he cover with the manure produced on his farm by 10 horses and 25 cows during 6 winter months?

WRITTEN PROBLEMS

1. 250 tons of mixed barnyard manure were produced on a farm in one year. All manure was well cared for and applied to the soil at the rate of 8 tons per acre.

(a) Determine the total amount of nitrogen, phosphorus and potassium contained in this amount of manure. (See oral problem 1, page 147.)

(b) Determine the total value of the fertility contained in this manure. (See oral problem 2, page 147.)

(c) Determine the value of the fertility applied per acre.

Average Composition of Fresh Manures—(Including Solids, Liquids and Bedding)

Animal	Per cent water	Per cent nitrogen	Per cent phosphorus	Per cent potassium	Fertility value per ton
Cow	77	0.44	0.07	0.33	
Pig	73	0.45	0.08	0.5	
Horse	70	0.58	0.12	0.44	
Sheep	64	0.83	0.17	0.56	
Hen	50	0.97	0.3	0.26	

2. On the basis of 15 cents per pound for nitrogen, 10 cents for phosphorus and 6 cents for potassium, determine the fertility value per ton of each of the manures in the above table.

3. In an experiment extending over 15 years at the Ohio Experiment Station, an 8-ton application of cattle manure per acre once in a five-year rotation resulted in an average increase per rotation of 13.55 bushels of corn and 517 pounds of stover; 6.2 bushels of oats and 359 pounds of oat straw; 7.24 bushels of wheat and 836 pounds of wheat straw; 1,052 pounds of clover hay and 1,007 pounds of timothy hay. When corn is worth 50 cents per bushel, oats 40 cents, wheat 90 cents, stover $3 per ton, straw $2 and clover and timothy hay each $8, determine the real value of the manure per ton from the value of the increased crop production.

4. During the same time that the above test was made, a 16-ton application of manure per acre in each five-year rotation resulted in an average increase per acre per rotation of 18.12 bushels of corn and 577 pounds of stover; 10.83 bushels of oats and 688 pounds of straw; 10.94 bushels of wheat and 1,277 pounds of wheat straw; 1,977 pounds of clover hay and 1,549 pounds of timothy hay. At the same prices as given in problem 3—

(a) Determine the real value per ton of the manure applied.

(b) Which method produced the greater value of crop increase per acre? What per cent greater?

(c) Which method produced the greater value of crop increase per ton of manure applied per acre and how much more?

(d) What is the practical lesson to be learned from results of problems 3 and 4?

5. A chemist* found a ton of fresh steer manure to contain 10.3 pounds of nitrogen, 3.24 pounds of phosphorus and 8.14 pounds of potassium. After three months' exposure to the weather in the barnyard he found the same manure to contain 0.359% nitrogen, 0.123% phosphorus and 0.167% potassium.

(a) Determine the per cent of loss of each of the fertilizing elements.

(b) Determine the per cent of loss of total fertility.

(c) What is the value of the fertility lost per ton? (See problem 2.)

(d) If 250 tons of manure were left exposed with similar losses, what would be the value of the fertility lost?

*Ohio Experiment Station Bulletin 183, page 205.

6. A farmer applied sheep manure to his soil at the rate of 18 loads per acre, each load averaging $1\frac{1}{2}$ tons. If this manure has the chemical composition as given in the preceding table (page 149), what was the value of the fertility applied per acre?

(a) If he secured a tobacco crop yielding 1,600 pounds of leaves per acre and sold the crop for 22 cents per pound, what were the profits per acre after deducting 50 per cent of the value of the fertility applied?

(b) If $\frac{1}{3}$ of the fertility contained in the manure is leached out of the soil after this heavy application of manure is made, determine the value of the fertility lost.

7. At the beginning of a 4-year rotation a farmer applied 20 tons of sheep manure per acre. The following crops were grown:

1st year—corn yielding 75 bushels of shelled corn.
2nd year—oats yielding 65 bushels per acre.
3rd year—barley yielding 45 bushels per acre.
4th year—red clover yielding 2.5 tons per acre.

(a) Determine the amount of nitrogen, phosphorus and potassium added to the soil per acre in the manure.

(b) Assuming no loss of fertility through leaching from the soil, determine the loss or gain of fertility during these four years. Assume clover to leave as much nitrogen in the soil as it took out. (See table on page 240 for crop requirements.)

8. A man believes he is maintaining the fertility of his soil when he applies 8 tons of average mixed barnyard manure per acre once in a four-year rotation, as follows:

1st year—corn (manured)—yielding 60 bushels of shelled corn.
2nd year—corn yielding 40 bushels of shelled corn.
3rd year—oats yielding 40 bushels per acre.
4th year—red clover yielding $1\frac{1}{2}$ tons per acre.

(a) Assuming no loss through leaching, of the fertility applied, determine the gain or loss of nitrogen, phosphorus and potassium per acre during these four years.

(b) Determine the loss or gain if the clover crop were plowed under.

(c) When one cow produces 80 pounds of manure per day and all is saved and applied to the soil, about how many cows must be kept per 100 acres to produce enough manure in one year to return to the soil the amount of fertility removed by these crops?

COMMERCIAL FERTILIZERS

ORAL PROBLEMS

1. When rock phosphate contains 13% phosphorus and costs $7.80 per ton, what is the cost of one pound of phosphorus? How many pounds of the element phosphorus to the dollar?

2. When acid phosphate contains 7% phosphorus (P)*, and costs $18.20 per ton, what is the cost of one pound of phosphorus (P)?

3. When basic slag analyzes 8% phosphorus, how many pounds of phosphorus are added to the soil when 300 pounds are applied per acre?

4. Muriate of potash contains 43% potassium. How many pounds of this element are added to an acre when 200 pounds of this potash fertilizer are applied?

5. At 55 dollars per ton what is the cost of 100 pounds of sulphate of potash?

*"P" is the chemical symbol for the element phosphorus.

6. One and one half tons of sulphate of potash contain 105 pounds of potassium (K)*. What per cent "K" does this potash or potassium fertilizer contain?

7. Nitrate of soda contains on an average 15% nitrogen. How many pounds of nitrogen in one ton of this nitrogen fertilizer? When nitrogen is valued at 15 cents per pound what is the value of one ton of this fertilizer?

8. One hundred pounds of ammonium sulphate contain 20 pounds of nitrogen. What is this fertilizer worth per ton when nitrogen is worth 15 cents per pound?

9. One ton of dried blood contains 280 pounds of nitrogen (N)†. What per cent "N" does this fertilizer contain?

10. A mixed or complete fertilizer contains $1\frac{1}{2}$% nitrogen (N), 4% phosphorus (P), and 3% potassium (K). How many pounds of each of these fertilizing elements are contained in two tons?

11. When unleached wood ashes contain 5% potassium and 40% carbonate of lime, how many pounds of potassium in 5 tons. Carbonate of lime?

WRITTEN PROBLEMS

1. How many pounds of pulverized limestone containing 36% calcium is required per acre to return to the soil the amount of calcium removed by a 3-ton red clover crop? (See table, page 240.)

2. If from a soil producing 6 tons of alfalfa hay per acre per season, 200 pounds of calcium is lost by leaching of water through the soil, how many pounds of pulverized limestone analyzing 36% of calcium would it take to replace the total loss of calcium to the soil? (See table, page 240.)

*"K" is the chemical symbol for the element potassium.
†"N" is the chemical symbol for the element nitrogen.

3. Determine the cost of one pound of the element potassium (K) in each of the following potassium fertilizers:

Muriate of potash containing 43% K, costing $46 per ton.
Sulphate of potash containing 42% K, costing $56 per ton.
Kainit containing 12% K, costing $15 per ton.

4. A pint of rock phosphate weighs about one pound. How much of this phosphorus fertilizer* should be sprinkled in the gutters in a barn per cow per day in order to give a 1,000-pound application per acre when 10 tons of manure are added to an acre? (See problem 3, page 147.)

(a) This amount of rock phosphate adds an amount of phosphorus equal to that amount removed by how many 60-bushel oat crops? By how many 6-ton alfalfa crops?

5. Manure applied to a soil low in phosphorus proves an unbalanced fertilizer. How many pounds of rock phosphate containing 13% phosphorus must be mixed in a ton of average mixed barnyard manure to raise the phosphorus content up to 0.8%, thus making a more balanced fertilizer for such a soil? (See Figure 17.)

The fertilizing constituents in a mixed or complete commercial fertilizer are usually expressed in terms of nitrogen (N), "phosphoric acid" (P_2O_5)† and "potash" (K_2O).‡ A "2-8-10" mixed or complete fertilizer, for example, means one that contains 2% nitrogen (N), 8% "phosphoric acid" (P_2O_5) and 10% "potash" (K_2O).

Give the meaning of the following fertilizers: "1.5-5-8," "3-10-8," "1-6-3."

*To render rock phosphate more soluble and hence more available to crops it is best to mix it with manure or plow it under with green manuring crops, like clover, when it is applied.

†"Phosphoric acid" is a chemical compound containing the elements phosphorus and oxygen, 2 parts of phosphorus combined with 5 parts of oxygen; hence the chemical symbol "P_2O_5."

‡"Potash" is a chemical compound containing two parts of the element potassium united with one part of oxygen, hence the chemical symbol "K_2O."

Rules:

(a) To reduce "phosphoric acid" (P_2O_5) to the element phosphorus (P), multiply the per cent or amount in pounds of "phosphoric acid" (P_2O_5) by .436.

(b) Per cent or amount in pounds of "potash" (K_2O) $\times$ .83 = per cent or amount of the element potassium (K), respectively.

6. 33% of "phosphoric acid" (P_2O_5) is equivalent to what per cent of the element phosphorus (P)?

7. 632 pounds of "P_2O_5" is equivalent to how many pounds of "P"?

8. 50% "potash" (K_2O) is equivalent to what per cent of the element potassium (K)?

9. 350 pounds of "K_2O" = how many pounds of "K"?

10. A firm advertises a brand of rock phosphate containing 13% phosphorus (P) at \$8 per ton. Another firm advertises the same kind of fertilizer under a different brand as containing 32% "phosphoric acid" (P_2O_5) for \$8.25 per ton. Which brand will give the greater amount of phosphorus for one dollar and how much more?

11. Four tons of a potash, or potassium, fertilizer, which analyzes 16% "potash" (K_2O), contains how many pounds of the element potassium (K)?

12. A low grade, mixed, commercial fertilizer, containing 1.1% nitrogen (N), 3% phosphorus (P) and 2.5% potassium (K), sells for \$24.50 per ton.

(a) Determine the amount of each of the plant-food elements in one ton. (Use no pencil.)

(b) When "N" in mixed fertilizer is valued at 20 cents a pound, "P" at 8 cents, and "K" at 6 cents, determine the fertility value per ton.

(c) What is the excess of selling price over fertility valuation?

13. A high grade, mixed, commercial fertilizer containing 3.5% nitrogen (N), 3.6% phosphorus (P) and 6.6% potassium (K), sells on an average, for $36.50 per ton.

(a) Compare this fertilizer with the low grade in points brought out in (a), (b), (c). Prob. 12.

(b) Is a low grade, mixed, commercial fertilizer necessarily "cheap"?

14. A farmer was advised to apply a fertilizer containing potassium and phosphorus to some drained peat* soil he had. He purchased muriate of potash containing 43% potassium costing him $46 per ton, and acid phosphate containing 7% phosphorus costing him $18 per ton. He mixed the two in equal proportions and applied the mixture broadcast at the rate of 350 pounds per acre. This treatment resulted in an average yield of 40 bushels of corn per acre which was 7 times greater than the yield on an unfertilized acre.

(a) The mixture applied contained what per cent potassium (K)? Phosphorus (P)?

(b) How many pounds of each element did he apply per acre?

(c) What did the application cost him per acre?

(d) What did the potassium and phosphorus cost him per pound?

(e) How much of the low grade, mixed fertilizer (Problem 12) would have been necessary to add the same amount of potassium per acre? What would the cost have been? How much money was saved in "home-mixing"?

*_Peat_—a marsh soil consisting largely of organic matter, hence containing much nitrogen and comparatively small amounts of potassium and phosphorus. (See page 135, Figure 18.)

(f) Compare the value of the increased yield of corn with the cost of the fertilizer applied.

(g) Compare the amount of fertility added with that removed by the crop. (See table on page 240.)

(h) Compound a mixture of these two fertilizers and determine the amount necessary to add as much potassium and phosphorus as is removed by a 50-bushel corn crop.

15. How many pounds of nitrate of soda containing 15% nitrogen, acid phosphate containing 7% phosphorus, and muriate of potash containing 42% potassium must be used to make a ton of a mixed fertilizer analyzing 3.5% nitrogen, 4% phosphorus and 6.3% potassium?

(a) How many pounds of "filler" must be used to make this mixture equal a ton in weight?

(b) When nitrate of soda costs $45 per ton, acid phosphate $18, and muriate of potash $46, determine the cost of the fertilizers to compound this mixture. Compare this cost with that of the low grade and high grade fertilizers in problems 12 and 13.

(c) Mention advantages in home-mixing of fertilizers.

16. Assuming that the amount of nitrogen in alfalfa hay is gathered from the air, determine the amount of fertility removed from an acre in four years when the average yield per season is 5.5 tons.

(a) How many pounds of muriate of potash and acid phosphate would be required to return to the soil the amount of phosphorus and potassium removed during those 4 years?

Figure 20.—Results of Manure vs. Mineral Fertilizers on Peat. On this marsh soil, deficient in both phosphorus and potassium, muriate of potash with rock phosphate proved to be the more economical fertilizer treatment. Courtesy of Wis. Exp. Sta.

(b) Compound a mixture of these two fertilizers and determine the amount of the mixture to be applied per acre as a top-dressing* to return to the soil the fertility removed annually.

(c) Would you apply nitrogen fertilizer to the alfalfa as a top-dressing? Why?

17. A farmer applied 18 tons of good, mixed barnyard manure per acre to some well-drained peat soil and was disappointed with results produced the second year after application. If applied to upland soil it would have continued in its effect.

(a) This soil needed no nitrogen. Determine the amount of nitrogen applied per acre from which he received very little or no returns.

(b) Determine the value of the useless nitrogen applied per acre at 15 cents per pound.

(c) How many pounds of potassium and phosphorus, which no doubt produced the results, were applied? Determine their value. (See page 149.)

*Since the potassium and phosphorus compounds in muriate of potash and acid phosphate are soluble, these fertilizers can very well be used for top-dressing.

(d) How many pounds of muriate of potash and basic slag could have been applied per acre to add the same amount of potassium and phosphorus as was added in the manure? (See page 152, problems 3 and 4.)

(e) Determine the cost of the required amount of muriate of potash and basic slag (problem d), and compare it with the value of the manure applied. (Consider basic slag costing $16 per ton.)

Points Worth Remembering:

1. Barnyard manure is a valuable fertilizer and should be well cared for and used intelligently.

2. The proper use of fertilizers depends largely on the soil and crops to be grown.

3. Some legume should be given a place in every system of crop rotation.

Name other points of practical value you have learned from the problems in this chapter.

CHAPTER XI

FARM MANAGEMENT

A little farming done on paper at times produces surprising results. One progressive farmer went so far as to say that the pencil is the greatest implement in promoting better agriculture. It is only when a man knows the cost of the feed he fed his hogs, for example, that he knows for a certainty whether or not he is paid for his labor. Some farm accounts have shown that some farmers have actually paid a good price for the privilege of doing good, physical exercise on their farms. The application of business principles is required to determine losses and gains.

ORAL PROBLEMS

1. From a test made in Ohio it was found that the feed-cost per chicken per year averaged 61 cents. What would be the cost of feed for a flock of 80 chickens?

2. It was also found that the average labor cost per chicken per year averaged 28 cents. Determine the annual cost of labor for a flock of 80.

3. When interest on investment, shelter and depreciation amounted to 6 cents per chicken per year, determine the total annual cost for the flock of 80.

4. When the average hen produces 6 dozen eggs annually, how many are produced by a flock of 80?

5. When the eggs sell for an average of 20 cents per dozen, determine the average labor income* from this flock of 80.

*Labor income is profits above total costs, including interest on investment, and may be compared to the wages paid to hired help.

6. When one bushel of corn produces 10.5 pounds of pork worth 8 cents per pound, how much is realized per bushel of corn?

7. A farmer has 120 acres of tillable land on his farm on which he keeps 25 cows. How many acres per cow?

8. A farm having 4 tillable acres per cow would receive how many tons of manure per acre once in a four-year rotation, when a cow produces an average of 13 tons barnyard manure annually? Will this maintain fertility?

9. When 16 tons of manure are applied per acre and are valued at $1.50 per ton, how many bushels of corn at 50 cents per bushel must be raised to offset 50% of the value of manure applied?

(a) The following year how many bushels of barley at 80 cents per bushel are required to offset 30%* of the value of the manure applied for corn?

(b) The third year how many bushels of oats are required to offset 20% of the value of the manure applied for corn?

10. A man paid $200 per acre for some land. What is the value of this land as an investment, when he realizes a profit of $12 per acre above total cost in sale of crops? (5% land rental† is included in the cost of crop production.)

SOLUTION: In gaining the net profit of $12 per acre, $10 per acre as land rental was charged against the crops. Thus the man realized 5% on the price paid, or invested in the land. Even though no profits were realized, but since a profit of $12 was realized, this is equal to 5% on $240, (12 ÷ .05). As an investment, therefore, each acre is equal to $440 at 5%.

11. A grain farmer, on account of poor crops, realized no profits above cost of producing his crops. In his cost accounting, $8.75 per acre as land rental at 5% was charged against the crops. What value was placed on the land?

*50% of the value of manure applied is commonly charged against the first crop, 30% against the second, and 20% against the third crop.

†Land rental is an item of expense in cost accounting charged against crops. The total cost in raising and marketing crops includes this item, which is usually reckoned at 5%. This is to cover interest charges, taxes and insurance.

12. Excluding the land rental of 5%, the annual profits above other costs realized from crop values on a rich, prairie soil were $42.50. In capitalizing these profits what is the land worth as an investment from the standpoint of producing power?

13. When it costs on an average about $14 on 100-dollar land to grow an acre of corn, how many bushels must be raised per acre to offset this cost when corn is worth 50 cents per bushel? ($5 of the cost is land rental at 5%.)

14. On this basis about how much is land worth per acre as an investment* that raises 48 bushels of corn per acre without increasing the cost except that of land rental, which is usually considered at 5%? (Take same value for corn.)

15. In the Middle West it costs approximately $60 per year to maintain a dairy cow. How many pounds of milk, selling for $1.50 per hundred, must be produced to offset this cost? How many pounds does this average per day when lactation period is 300 days?

WRITTEN PROBLEMS

Miscellaneous:

1. A young farmer invested $20 in a 1,000-pound portable scales.

(a) He sold his barley for 70.5 cents per bushel. He weighed the contents of each load before leaving the farm. The first load detected a defective buyer's scales which underweighed 2.1 lbs. on a bushel. How much money would he have *lost* had he not known the weight of his loads, when he was credited for correct weight for 800 bushels?

*See footnote, page 173.

(b) Determine the per cent gained on money invested in the scales.

(c) He fattened 20 hogs and was offered $325 as a lump sum for them by a local stock buyer, when hogs like his were quoted at $7.35 per hundred. He asked $352, knowing the average weight. The following day he took his pigs to market and found that they averaged 253 pounds, and received $7.30 per hundred pounds.

How much money did the scales save him when offered sum is considered?

2. A good farmer spent half an hour in teaching his hired man to make good, round shocks of barley properly capped with two sheaves, each shock containing 12 bundles. A rainy week resulted in little coloring of the grain other than the cap sheaves, which were threshed separately. Because of better color, $3\frac{1}{4}$ cents more per bushel were realized for his barley. He sold $\frac{9}{10}$ of his crop of 15 acres averaging 40 bushels per acre. How much was he paid for the one half hour spent in teaching his hired man how to do a small job right?

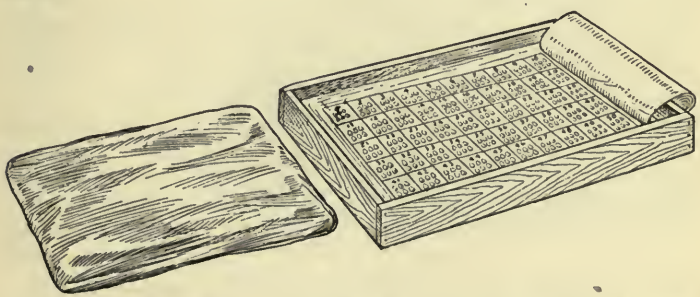

Figure 21.—A Simple Method for Testing Corn. Upon muslin cloth squares are drawn and numbered, upon which are laid the kernels from each ear to be tested. When the tester is filled, a moist, sawdust pad, shown at left, is placed on top. Courtesy of Wis. Exp. Sta.

3. A man failing to test the greater portion of his seed corn secured $\frac{3}{8}$ of a crop as compared with the tested seed. The yield of the poor corn averaged 25 bushels of shelled corn per acre for 25 acres. When corn is worth 65 cents per bushel, determine the cost of carelessness.

4. Sixty bushels of seed oats were given the formalin seed treatment* for loose smut at a cost of $3\frac{1}{3}$ cents per bushel (including labor cost). Three bushels were sown per acre, which yielded 65 bushels per acre, which was a 12% increase over an untreated acre. Determine the percent profit on cost of treatment when oats are worth 38 cents per bushel.

5. A man raised 20 acres of a high grade, pure-bred oat, averaging 70 bushels per acre. He needed the oats for feed, but had the opportunity to sell his crop for seed at 75 cents per bushel. Doing so, he purchased the same amount of oats for feed at an auction sale for 35 cents. Allowing 4 cents a bushel as cost in making the exchange, what were his profits above cost of labor?

Figure 22.—Results of a Test. A Section. The ears from which the weak and sterile kernels were taken should be thrown out. Courtesy of Wis. Exp. Sta.

6. Mr. "A" took good care of his grain binder which

*One pound (pint) of formalin in 30 gallons of water for 50 bushels of oats. Solution is sprayed on grain and thoroughly mixed or dipped in loosely filled burlap sacks for 2 hours.

cost him $125. He used it 14 years, each year cutting an average of 50 acres of grain. Repairs averaged $4.75 per year (including cash and labor repairs). The value of the machine each year was inventoried as follows:

$125, 80, 75, 75, 65, 65, 60, 60, 50, 45, 40, 25, 20, 15.

(a) Determine the average yearly investment* made in this machine.

(b) At 6% what is the interest on the total investment for the 14 years? Average yearly interest?

(c) Determine the average yearly cost of the machine.

(d) Determine the average machinery cost per acre of grain per year.

7. Mr. "B" kept his grain harvester, costing the same price, out of doors the year round, cutting on an average

Figure 23 —Going to the Junk Pile. What must be the depreciation of a high-priced machine cared for like this? Is it a profitable investment? Courtesy of Country Gentleman.

*Average yearly investment in this case is the sum of the yearly values divided by 14.

of 45 acres for 8 years. Repairs averaged $7 per year. Inventory for each year showed value of machine as follows: $125, 60, 50, 40, 30, 25, 20, 15.

Make the same determinations as in (a), (b), (c), (d), problem 6.

8. In a test made on a heavy, silt loam, corn planted in hills 3 feet 8 inches each way, thoroughly and scientifically cultivated, yielded 74.8 bushels of shelled corn per acre and 2.03 tons of field-cured stover. Corn not cultivated, but having weeds cut without stirring the soil, yielded 44.6 bushels per acre and 1.66 tons of stover.

(a) What was the per cent of increase in yield of shelled corn? Stover?

(b) When corn is worth 55 cents per bushel and stover $3 per ton, what was the value of the increased yield, due to thorough cultivation?

9. A farmer hired cheap labor in the form of a boy at 75 cents per day to cultivate a 15-acre field of young corn planted in hills 3 feet 8 inches apart each way. It was cultivated twice in a row with a one-horse walking cultivator and cultivated both ways. $2\frac{1}{2}$ acres were worked each day.

(a) What did it cost in cash for labor to cultivate that corn two ways? How much per acre?

(b) The boy through carelessness covered up and dug out on ends and in field, on an average, one hill out of 11. Assuming that the yield was reduced proportionately, what was the loss in the crop, when the corn averaged 60 bushels of shelled corn and 3 tons of stover per acre?

(c) What was the real price paid per day for hiring the careless and inefficient boy when corn is

worth 50 cents per bushel and stover $3 per ton?

(d) What would have been the saving in the end had the farmer hired a good man at $2 per day, doing the same amount of work, but having no corn destroyed?

10. A man sold a high grade Guernsey cow for $150 and thought he had made a good bargain. The buyer found that this cow produced 13,560 pounds of milk in 300 days, testing 4.5% fat. The cost of feed averaged 18 cents per day for 300 days. 2,437 pounds of 25% cream were sold at 25 cents per quart*.

(a) Assuming the value of the manure produced and the calf offset labor cost, determine the net profits. Consider 6% interest on money invested in the cow, feed cost, value of skim milk at 15 cents per hundred and cash returns for cream.

(b) Suppose the man selling the cow sold the feed required to feed that cow for $25, and put all money received (including money received for cow) out at 6% interest. What would have been his net income from this investment per year?

(c) Suppose he kept the cow and valued her at $150; fed her a ration costing 16 cents per day for 300 days; and sold $\frac{2}{3}$ as much milk as was produced by the buyer of the cow at $1.35 per hundred. Determine gain or loss as in (a). Compare results with (b).

*One gallon of 25% cream weighs approximately 8.35 pounds.

Profit and Loss in Feeding:

11. A man produced 11.6 pounds of pork, on an average, from each bushel of corn fed. When pork was sold for $8.30 per hundred pounds, what did he realize per bushel for his corn?

12. A feeder produced 10 pounds of pork, on an average, for each bushel of corn fed.. When corn is worth 75 cents and hogs sell for $6.60 per hundred weight, what does he gain or lose on each 100 pounds of pork produced?

13. Over 500 feeding trials* show that pigs weighing between 150 and 200 pounds consume, on an average, 5.9 pounds of feed per pig per day, producing, on an average, a daily gain of 1.2 pounds; and pigs weighing between 300 and 350 pounds consume 7.5 pounds of feed per day, producing a daily gain of 1.4 pounds.

(a) Determine the number of pounds of feed required to produce 100 pounds of gain in each case.

(b) How many more pounds of pork could be produced in feeding the younger pigs from the amount of feed required to produce 5,580 pounds of gain in feeding the older and heavier pigs?

(c) Name other advantages in fattening younger pigs.

14. A man figured that he had 12.5 tons of corn silage and 8 tons of alfalfa more than he needed to supply his dairy herd. He borrowed money at 6% on 9 months' time and bought 3 cows at $75 per head. At the end of 9 months, they were sold at $60 per head. The cows averaged 20 pounds of milk a day for 9 months. The cost of extra concentrates fed each cow was $14. Milk was sold at $1.35 per

*Henry and Morrison's Feeds and Feeding.

hundred. Assuming that the value of the manure produced and the calves was sufficient to offset the cost of labor, did this man gain or lose in his feeding when he could have sold his surplus silage for $3 and alfalfa hay for $15 per ton?

(a) How would the accounts stand, if the cows each gave 30 pounds per day?

(b) At this price of milk how much should each cow have averaged per day to balance accounts?

(c) If the milk were sold for 3 cents per quart* in the original problem, what would have been the profit or loss?

15. A man purchased 2,000 lambs averaging 60 pounds for $6 per hundred pounds including freight. He fed them for 90 days on pea silage, costing $1 per ton, at the rate of 3.5 pounds per lamb per day, and grain (screenings) which cost 5 cents for every pound of gain. He sold them on the Chicago market for 8 cents a pound—they averaged 84 pounds. Freight charges averaged 27 cents per lamb. Loss from death was one per cent of the original number. Labor cost was estimated at 1 cent per pound gain. 150 tons of manure were produced per month.

(a) What was the daily gain per head? Per flock?

(b) Determine the total net profits—consider interest on money invested in the lambs at 6% and value of manure in the yard at $1.50 per ton.

(c) What were the profits per head?

(d) At $15 per ton, how many tons of screenings were fed? Average per lamb per day?

(e) How many lambs were required to consume one ton of pea silage per month?

*One gallon of milk weighs 8.59 pounds, or 11.6 gallons weigh 100 pounds.

16. The following is an itemized statement made by a feeder who fed 20 steers:

	Total	Av. per head
Number of steers bought	20	
Weight		1,050 pounds
Number of pigs bought*	10	
Weight		150 pounds
Cost of steers at 7.5c. per lb. delivered		
Cost of pigs at 7.5c. per lb. delivered		
Feed consumed by steers	Alfalfa 10 tons, broken ear corn 18 tons, cottonseed meal 1.02 tons	
Cost of feed: Alfalfa at $16 per ton		
Corn at 50c. per bushel		
Cottonseed meal at $28 a ton		
50 bu. ear corn for pigs at 50c. per bushel		
Freight charges in marketing steers		$1.87
Cost of yardage for steers		.25
Cost of hay on market	$1.00	
Commission in selling		.50
Interest on money invested in steers at 6% for 4 mo.		
Interest on money invested in hogs at 6% for 4 mo		
Selling weight of steers		1,305 pounds
Selling price of steers at 8c.		
Selling weight of hogs		225 pounds
Selling price of hogs at $7.50 per hundred		
Manure produced from steers	85 tons	
Value of manure at $1.25 per ton		

(a) Complete the above itemized statement.

(b) Select the items of expense and of income and determine profit and loss in this feeding venture. (Cost of labor was not included.)

*One pig following two steers was considered sufficient, since the steers were fed broken ear corn.

(c) What would have been the profit or loss if no pigs followed the steers?

(d) Determine the cost of feed per pound of gain in the steers.

(e) Determine the total cost per pound of gain in the steer-feeding venture, cost of labor excluded.

17. A farmer decided to test his herd of 10 cows and keep a milk record to ascertain the worth of each individual. At the end of the year he had on hand the following data:

Cow	Milk produced Pounds	Average test	Lbs. butter-fat	Value of fat at 30c. per lb.	Inventory value	Cost of feed	Net returns
1....	3,624	3.84%	.....	.....	$50	$43	.....
2....	9,546	4.5 "	.....	.....	80	60	.....
3....	6,145	3.6 "	.....	.....	60	50	.....
4....	7,254.5	5.0 "	.....	.....	75	55	.....
5....	3,933	3.8 "	.....	.....	50	44	.....
6....	1,838	4.1 "	.....	.....	30	43	.....
7....	6,542	4.8 "	.....	.....	70	50	.....
8....	3,830	3.34 "	.....	.....	50	45	.....
9....	6,874	3.8 "	.....	.....	70	52	.....
10....	6,740	4.3 "	.....	.....	70	52	.....

All feeds were raised on the farm. The value of the calves, skim milk and manure were regarded as sufficient to offset the cost of feed during time cows were dry, and labor cost throughout the year.

(a) Determine the pounds of butter-fat produced by each cow. Value at 30 cents per pound.

(b) Determine net returns above cost of feed for each cow.

(c) Determine the total net returns for the herd. Average per cow.

(d) Determine the total net returns from the four best cows. Compare this amount with the total net returns from the remaining six.

(e) How many cows averaging as the six poorer cows would be required to produce as much net profits as the four best cows?

(f) How many cows like No. 5 would be required to produce net returns equal to cow No. 2?

Figure 24.—A Profitable Dairy Cow. This cow produced in one year 563 pounds of butter-fat. Above cost of feed she netted her owner $104.70. Courtesy of Wis. Agr l Exp. Sta.

(g) Suppose the man had sold cows Nos. 1, 5, 6, and 8 at the stated values and the feed required for each of these cows for the values given, and invested all the money received at 6% for one year, determine the total net returns in this change in management of the herd. Compare with results obtained in problem (c).

(h) Suppose the four poorest cows were sold for the values given them and the money invested in two cows which were fed the feeds required to feed the four poor cows, and each produced, on an average, 10,350 pounds of milk testing 4%. Determine the net returns for the herd under these conditions. Compare results with problems (g) and (c).

18. A man set out to determine the true* value of the best and poorest cows in his herd of 12 grade Shorthorns. With some help he got the following data covering one year:

	Star (best cow)	Nig (poorest cow)
Lactation period	305 days	295 days
Milk produced	10,550 lbs.	5,810 lbs.
Average butter-fat test	4.1%	3.6%
Amount of 25% cream sold	1,725 lbs.	834 lbs.
Value of fat in cream at 25c. per lb.		
Amount skim milk		
Value skim milk at 15c. per hundred		
Average cost of feed per day	$ .20	$ .16
Labor cost during lactation period	18.50	18.50
Cost of shelter	2.46	2.46
Miscellaneous expense other than interest on investment and depreciation	3.25	2.60
Beef value	60.00	60.00

The value of the manure and the calves was supposed to cover the cost of labor and feed while cows were dry.

(a) Determine the items left blank.

(b) Assuming that the maximum productive period of a cow is 6 years, the profit per year should be considered at 20%† of her value as capital above her value for beef. Determine the real value of each cow.

*True value of a cow is obtained by capitalizing her net profits. Land, for example, which produces a profit of $5 per acre above total costs, excluding interest on investment at 5%, is capitalized at $100 from the standpoint of producing power. (See also problems 10-12 oral and page 69, Part I.)

†20% charges are made to include interest on investment, depreciation, etc. Capitalizing net profits necessarily increases interest charges and depreciation, etc.

Figure 25.—The Products of a Poor, a Good, and an Exceptionally Good Dairy Cow. Large tubs each contain 60 lbs. butter. Many dairy cows do not pay for their board. Courtesy of Wis. Exp. Sta.

Profit and Loss in Manuring and Fertilizing and in producing Crops:

19. A farmer having some acid, silt loam, purchased some pulverized limestone at $2.25 per ton. Freight charges were 2.5 cents per hundred. Getting it on the land cost 75 cents per ton. Extra harrowing to work lime into soil cost 50 cents per acre. Two tons were applied per acre. The following year the clover yielded 2.8 tons per acre on the limed area—an increase of 63.3% over the unlimed area.

(a) Charging 50% of the cost of liming against the first clover crop, determine the per cent profit on cost of liming when clover hay is worth $9.75 per ton.

20. The plowing under of a green-manuring* crop of cowpeas equivalent to 2 tons of hay per acre resulted in a yield of 76 bushels of shelled corn per acre, which was an increase of 55% over the yield on an area having received no green-manuring.

*Green-manuring is the plowing under of green crops which were sown for that purpose.

(a) How many pounds of nitrogen were contained in the cowpea crop plowed under? (See page 240.) Value at 15 cents per pound?

(b) When corn is worth 65 cents per bushel, determine value received from plowing under this green-manuring crop.

21. The standard fertilizer for cotton adopted by the Georgia Experiment Station is a mixture of 468 pounds of acid phosphate (containing 7% phosphorus); 36 pounds of muriate of potash (containing 41.5% potassium); and 130 pounds of nitrate of soda (containing 16% nitrogen), to be applied per acre in one application by drill before planting.

(a) Determine the number of pounds of each fertility element added per acre when this mixture is applied.

(b) When muriate of potash costs $45 per ton, acid phosphate $15.20 and nitrate of soda $45 per ton, what is the cost of this application per acre?

(c) If such a treatment results in a yield of 460 pounds of lint per acre, which sells for 12 cents per pound, determine the profits above cost of fertilizers.

22. On a peat* soil in Wisconsin a fertilizer test was made as indicated in the following diagram, which shows the kinds and rate at which fertilizers were applied per acre:

No. 1	Barnyard manure—15 tons per acre
No. 2	Muriate of potash—400 lbs. per acre Acid phosphate —600 lbs. per acre
No. 3	No treatment
No. 4	Muriate of potash—400 lbs. per acre

*See footnote concerning peat on page 156.

The fertilizers were applied broadcast.

Two crops of corn were grown following the above treatment, yielding per acre as follows: Strip No. 1, first year, 10.5 tons of corn fit for the silo, second year, 5.8 tons; Strip No. 2, first year, 16.8 tons, second year 14.2 tons; No. 3, first year, 3.25 tons, second year, 3.8 tons; No. 4, first year, 13.9 tons, second year, 13.4 tons.

(a) Determine the value of the fertility contained in the manure applied per acre. (See page 147.)

(b) What was the value of the fertility contained in the manure applied per ton of increase in corn over the yield on the strip having received no treatment?

(c) When manure is valued at $1.50 per ton, determine the fertilizer cost per ton increase in the corn crop.

(d) When green corn is worth $2 per ton standing, what was the profit or loss in the use of manure on this soil? Use both values given the manure. Determine per cent profit or loss on values given manure.

(e) Determine the cost of the fertilizer application made on strip No. 2, when muriate of potash cost $46 per ton and acid phosphate, $18.

(f) What did it cost in fertilizers to produce one ton increase on this strip?

(g) When green corn is worth $2 per ton, determine the per cent profit realized on cost of fertilizers, Strip No. 2.

(h) Determine the cost to produce one ton increase, and per cent profit realized on cost of fertilizer applied to strip No. 4. Compare these results with strips Nos. 1 and 2.

(i) Mention some lessons that may be learned from these results. (See also Figures 18 and 20.)

(j) In comparing strips Nos. 2 and 4 which produced the greater amount of profits above cost of fertilizers? What per cent greater amount of profits? Which application, then, would you recommend as being the more profitable fertilizer treatment for this marsh soil, basing opinion on these 2-year results? Which application would appeal to the man of small means? To the man of ample means?

(k) If the money used to purchase fertilizers were to be borrowed for one year at 6%, which would be more profitable, to fertilize as on strip No. 2 or as on No. 4?

23. According to Government data collected in Rice County, Minnesota, to grow an acre of oats costs, on an average, as follows:

Operation	*Cost per acre*
Seed value	$0.962
Cleaning seed	0.021
Plowing	1.230
Dragging	0.258
Seeding	0.241
Cutting	0.380
Twine	0.377
Shocking	0.158
Stacking	0.767
Stack-threshing (labor)	0.632
Threshing (cash cost)	0.865
Machinery	0.446
Land rental*	3.500

(a) Determine the total cost to grow an acre of oats according to these figures. Cost per bushel, when yield is 45 bushels. When yield is 65 bushels, assuming costs remaining the same.

*Land rental covers interest charges, taxes and insurance. In this case land was valued at $70 per acre.

(b) When oats are worth 35 cents per bushel, at least how many bushels must be produced per acre to offset this cost?

(c) Determine the cost to grow an acre of oats when land is valued at $225 per acre. Assume 5% to cover land rental and other costs to remain the same.

(d) Suppose $10 worth of fertilizer were applied per acre to this 225-dollar land at the time of sowing the oats, and 50% of the cost of the fertilizer be charged to the oat crop; how many bushels of oats worth 34 cents per bushel must be produced per acre to offset this cost? Include 2 tons of straw valued at $2.50 per ton.

Figure 26.—Harvest Time. What does it cost to raise a crop of grain? Courtesy of Wis. Agr'l Exp. Sta.

(e) Suppose the fertilizer treatment mentioned in problem (d) resulted in an average yield of 75 bushels of oats and 2 tons of straw per acre —an increase of 15% over an unfertilized strip.

Determine profit or loss in fertilizing when oats are worth 35 cents per bushel and straw $2.50 per ton. Would it have been profitable were there a 20% increase in the crop? A 25% increase?

24. "A" raises on an average 40 bushels of corn and 2 tons of stover per acre at a cost of $9.55 per acre on low-priced land. "B" succeeds in producing on an average 75 bushels of corn and 3.4 tons of stover on highly fertilized and high-priced land at a cost of $35.20 per acre.

(a) When corn is worth 60 cents per bushel and stover $3 per ton, who realizes the greater per cent profits per acre?

(b) What per cent greater profits does the one realize over the other?

25. Mr. Brown invested $300 in fertilizers. He applied $10 worth per acre once in a four-year rotation and received a net profit as increased crop production, as total for the 4 years, amounting to $20 per acre above cost of fertilizer. Jones, having $150, invested only $5 worth of fertilizer per acre applied over an area equal to that fertilized by Brown, and, in the same period of time, received a net profit in increased crop yields amounting to $12.50 per acre above cost of fertilizers.

(a) Who received the greater per cent profit on fertilizer invested?

(b) Who made the more profitable investment, and how much more profitable?

(c) Suppose both men borrowed the money invested in fertilizers at 6% for 4 years. Who then would have made the greater per cent profit on fertilizers? Who would have made the more profitable investment? How much more profitable?

(d) Would it have been more profitable for Jones had he borrowed \$300 at 6% for 4 years and applied \$10 worth of fertilizer per acre and received a total increase for the 4 years of \$15 per acre above cost of fertilizer? How much more profits would he have gained as compared with problem (c)?

26. A farmer who succeeded in growing alfalfa on acid soil by liming and inoculating* figured profit and loss from the following figures:

Operation	*Cost per acre*
Cost of liming (initial cost)	\$5.84
Alfalfa seed (initial cost)	6.50
Inoculation (initial cost)	2.00
Fertilizer (Av. of 10% per yr. of value of manure applied to corn)*	3.00
Mowing (man and horse labor, 3 cuttings)	1.00
Raking	0.54
Cocking	0.60
Hauling in	3.00
Machinery cost	0.65
Land rental at 5%	7.50

Cost of preparation of seed bed was offset by value of nurse crop.

Returns:

Average yield for four years—4.6 tons of hay per acre.

Average value per ton—\$16.00.

(a) Determine the average profits per acre per year.

(b) Determine the value of this land as an investment,† growing alfalfa, when for every dollar the land is worth above \$150, 5 cents be charged against it to cover annual land rental.

(c) When before liming‡ it cost \$25 to produce 65 bushels of corn and 3 tons of stover per acre, husked and shredded, determine the value of

*Liming corrects acidity. Inoculation is necessary to supply the proper nodule-forming organisms.

†See footnote on page 173.

‡A crop of corn was raised on this land before the alfalfa.

this land as an investment when it produces this amount of corn, when corn is worth 65 cents per bushel and stover $3 per ton. For every dollar the land is worth above $150, 5 cents should be charged against it to cover annual land rental.

(d) From this point of view, is liming acid soils for growing alfalfa profitable? (See Figure 27.)

(e) Suppose this soil were well supplied with lime and required no lime and inoculation. Determine the value of the land as an income producer when alfalfa yields 5¼ tons per acre per season. (Solve as in (b).)

27. Determine the cost to produce a bushel of potatoes in your neighborhood. A bushel of corn. A bushel of oats.

Farm Records and Accounts:

28. The following is an account a farmer kept with his hired man for four months:

John Zoellmer
Commenced work March 1st, 1909, at $28 per month and board and room.

Mar.	10	Cash	$ 6	50	Apr.	1	1 month's work in March	$28	00
Apr.	1	Paid bill at store	4	40	May	1	1 month's work in April	28	00
Apr.	4	Cash	15	00	June	1	1 month's work in May	28	00
May	10	Cash	10	00	June	..	Did not work June 10-11	..	..
June	31	Cash	74	23	June	31	28 days' work in June	26	13
			$110	13				$110	13

(a) Make out an imaginary account with a hired man for six months.

29. The following brief account was kept by a farmer with 15 acres of mixed clover and timothy hay. Average for two years.

Figure 27.—Success with Alfalfa Due to Lime. Nine acres in this field of acid soil were limed and one acre left unlimed. The whole field was inoculated. Under ordinary conditions alfalfa cannot grow on acid soils unless first limed and inoculated with alfalfa nodule-forming organisms. Courtesy of Wis. Exp. Sta.

Account with 15 Acres of Hay (Av. for 2 years).

Charges*			Credits		
25% of value of manure applied to corn	$5	65	15 tons hay at $10.50 per ton		
Seed at 50 cents per acre			4 tons hay at 9.40 per ton		
Mowing at 40 cents per acre			8 tons hay at 9.50 per ton		
Raking at 18 cents per acre			Total credits and receipts		
Cocking, hauling and stacking at $1.30 per acre					
Machinery cost at 55c. per acre					
Land rental at $7.50 per acre					
Total costs					
Profits					
Grand total					

(a) Fold a sheet of paper to represent the left and right hand pages of an account book, rule as shown above, and complete the account.

(b) Determine net profits per acre.

*In the farm account book the opening inventory and charges to an account occupy the entire left hand page, and these items include cash paid out by you, work done by you, or any item of value for which you are not paid. The credit items, or what is received from an account, occupy the entire right hand page, and include cash paid to you, work done for you, value received for stock and farm products sold, and the closing inventory.

30. Fold a sheet of paper to represent the right and left hand pages of an account book, rule properly, and enter the following items under "charges" and "credits," as:

Account with 12 Acres of Potatoes.

Charges*				Credits†			
1913	Item	Amount		1913	Item	Amount	
May 25	.....	.....	....	Oct. 20	.....	....	....
.....	etc.....	.....	....	.....	etc.....	....	....

May 25, 1913, 135 bushels of seed potatoes at 55 cents per bushel; July 10, 10 pounds of Paris green at 22 cents; July 15, 7 pounds Paris green at 22 cents; 120 tons manure at $1.50 per ton; plowing at $1.60 per acre; dragging at 92 cents per acre; planting at $2.50 per acre; cultivating, $1.70 per acre; hoeing, $1.00 per acre; spraying, $1.60 per acre; digging, picking and hauling, $6.75 per acre; machinery cost, 35 cents per acre; land rental, $7.50 per acre; Oct. 20, sold 307 bushels at 56 cents per bushel; Oct. 25, sold 1,000 bushels at 63 cents; Nov. 3, sold 350 bushels for seed at $1.25 per bushel; saved for seed 150 bushels at 75 cents; kept for home use 75 bushels at 60 cents; fed 38 bushels small potatoes at 20 cents; estimated value of manure left in the soil, $108.

(a) What were the total profits?

(b) Determine average net returns per acre.

(c) Determine the average cost per bushel.

31. Fold a sheet of paper to represent the left and right hand pages of an account book, rule as in problem 29, and arrange the following summary items for a herd of 10 cows under "charges" on left hand page and "credits" on right hand page.

*Charges usually occupy the entire left-hand page of account book.
†Credits usually occupy the entire right-hand page of account book.

CHARGES

Opening Inventory: Jan. 1st, 1914, 3 cows at $45 each, 4 at $60 each, 3 at $75 each; 10 tons alfalfa hay at $16 per ton, 10 tons straw at $3 per ton (used for bedding), 50 tons corn silage at $3 per ton, $\frac{3}{4}$ ton ground corn worth $21 per ton, $\frac{1}{2}$ ton bran at $24 per ton and $\frac{1}{4}$ ton cottonseed meal at $28 per ton.

March 5, bought $1\frac{1}{2}$ tons ground corn at $20 per ton and $\frac{1}{2}$ ton wheat bran at $24 per ton; April 2, $\frac{1}{2}$ ton cottonseed meal at $28 per ton; June 10, harvested 6 tons alfalfa worth $16 per ton; July 21, 8 tons alfalfa hay worth $14 per ton; Aug. 21, 8 tons alfalfa hay worth $16 per ton; Sept. 23, 60 tons corn silage worth $3 per ton; Sept. 26, 15 tons straw at $3 per ton; Sept. 30, 1 ton ground corn at $22 per ton, 1 ton bran at $23 and $\frac{1}{2}$ ton cottonseed meal at $28 per ton; Oct. 30, $1\frac{1}{2}$ tons ground corn at $22 per ton and 2 tons bran at $24. Pasture for summer $25. Man and horse labor $22 per cow; shelter $2.45 average per cow; other expenses $3.50 per cow. Interest and taxes on amount invested at 6%. (Take average of the two inventories* to obtain amount invested.)

CREDITS

Milk was shipped to city market averaging $1.53 per hundred net.

Feb. 1, 6,400 lbs. sold in Jan.; Mar. 1, 7,400 lbs. in Feb.; Apr. 1, 7,500 lbs. in March; May 1, 6,800 lbs. in Apr.; June 1, 6,900 lbs. in May; June 5, 2 veal calves for $14; July 1, 8,900 lbs. in June; Aug. 1, 6,100 lbs. in July; Sept. 1, 4,200 lbs. in Aug.; Oct. 1, 3,000 lbs. in Sept.; Nov. 1, 5,400 lbs. in Oct.; Nov. 10, 3 veal calves, $18.50; Nov. 12, sold cow and calf for $95; Dec. 1, 7,200 lbs. milk for Nov.; Dec. 7, 1 veal

*See inventory under "credits." Closing inventory is commonly used as the opening inventory for the new year.

calf, $6.25; Dec. 31, 6,400 lbs. for Dec.; total milk for home use 1,500 lbs. at $1.53 per hundred. Manure for year 105 tons at $1.50 per ton.

Closing Inventory: Dec. 31, 3 cows at $45 each, 4 at $55 each, 2 at $72 each; 3 calves valued at $25; 12 tons alfalfa hay valued at $16 per ton; 5 tons straw at $3 per ton; 45 tons corn silage at $3 per ton; $\frac{1}{3}$ ton ground corn at $22; $\frac{1}{8}$ ton cottonseed meal at $28 per ton.

(a) Determine total profits or loss.
(b) What was the average feed-cost per cow?
(c) Determine the total cost per cow.
(d) Determine the total average returns per cow.

The Farmer's Income:

32. Government statistics for 1910 show that the average farm in the United States consisted of 138.1 acres, (75.2 acres improved land). The average gross income per farm was $980.55 and average total expenses were $340.15. Determine the average net farm income. (Use no pencil.)

33. The total investment per farm was $6,443.67. Determine the average labor income* per farm when interest on investment was figured at 5%.

34. The average farmer pays 6% on a mortgage averaging $1,715. How much money on the average is available for purchase of stock and for family use on the average farm in the United States?

35. Statistics† gathered from Tompkins County, N. Y., show that farmers on general farms averaging in size from 31 to 60 acres receive on an average an annual labor income of $254; while those on farms averaging from 150 to 200 acres receive $635. What per cent of the labor income from the small farms is the labor income from the larger farms?

*Labor or managerial income means profits above total costs—total costs including interest on investment and unpaid family labor. Family labor means all work done by wife and children on the farm, not including the household.

†New York, Cornell bulletin 295, p. 414.

36. Other statistics from the same county show that the average labor income from $2,000 to $4,000 invested in farm capital amounts to $240; while $10,000 to $15,000 in capital returns an average labor income of $870.

(a) Is the increase in labor income in proportion to increase in capital?

(b) Determine the average net farm income* in each case. Consider interest on investment at 5%.

37. Farmers "A" and "B" each have a 120-acre farm in which capital is distributed as follows:

	"A"	"B"
Land value	$15,000	$18,000
Live stock (mostly cows)	3,500	2,300
Farm buildings	4,800	9,250
Implements and machinery	650	2,860

(a) What per cent of A's capital is invested in land? B's?

(b) What per cent of A's capital is invested in stock? B's?

(c) What per cent of A's capital is invested in farm buildings, implements and machinery? B's?

(d) A's net farm income for one year was $3,456 and B's $1,233. When interest on investment is figured at 5%, what was A's labor income? B's?

(e) What was one of the troubles in B's farming?

38. In Tompkins County, N. Y., it was found that on land valued at from $21 to $40 per acre, the tenant's labor income per year averaged $402 and the landlord's profit on investment averaged 8.9%. On land valued at $60 and above, the tenant's labor income averaged $562 and the landlord's profit on investment averaged 6.4%.

*When labor income is the net farm income minus the interest on capital invested, the net farm income may be easily determined.

(a) For the tenant the higher priced land is how many per cent more profitable than land of less value?

(b) What per cent greater profits does the landlord realize when he rents the lower valued land than when he rents land of higher value?

39. The labor income on farms averaging in size from 150 to 200 acres in that county averaged $635 which was 150 per cent more than on farms averaging in size from 30 to 60 acres. Determine the average labor income on the smaller farms.

40. In Missouri it was found that small farms of 40 acres or less averaged $128 as labor income for the owner, which was 69.8% less than that from farms averaging 200 to 400 acres. Determine the average labor income for owners of the larger farms.

41. The following summary was made at a year's end on a successful dairy farm consisting of 211 acres, of which 160 are tillable.

Capital invested:	
Farm value at $60 per acre	
Machinery	$450.00
Horses:	
3 @ $175 each	
2 @ 75 each	
Cows:	
10 @ $85 each	
6 @ 75 each	
5 @ 65 each	
8 @ 45 each	
7 @ 40 each	
Other stock	320.00
Other items	116.00
Receipts (Cash):	
300 bu. barley @ 75 cents	
2 tons alfalfa hay @ $16 per ton	
2,500 bu. potatoes @ 50 cents	
259,200 lbs. milk @ $1.40 per hundred net	
Stock sold	260.00
Miscellaneous	43.00

Expenses:

Labor and board	$1,100.00
Feeds purchased	560.00
Fertilizer	108.00
Seed	64.00
Miscellaneous	286.00
Unpaid family labor* (estimated)	300.00

(a) Determine the total amount of capital invested in the farm.

(b) Determine the total cash receipts.

(c) Determine the total expenses.

(d) Determine the farm income.

(e) Determine the interest on investment at 5%.

(f) What was the labor or managerial income from this farm?

A Few Farm Facts:

1. The successful farmer is a good business man.

2. It is necessary for a farmer to keep accounts to determine profits, losses and labor income.

3. The farm is a poor place for the inefficient.

4. A farmer on a farm receiving a labor income receives in addition the use of a house and some products for home use.

5. Fewer farmers are needed to feed the world when better farming is practiced.

6. What facts brought out in the preceding problems especially interested you?

*Family labor includes labor done on the farm by the wife and children, work done in household excluded. This item is usually estimated.

CHAPTER XII

FARM MEASUREMENTS

The farmer frequently has occasion to map his farm, or a part of it, for use in working out crop rotation systems, in rearranging his fields, in building, etc. Such work can be more successfully done when diagrams are drawn to some scale. In some communities very few farmers can give the description of the farms they own. Almost every practical farmer should carry in his mind a few rules to enable him to work out the common problems in farm measurements.

ORAL PROBLEMS

1. A Congressional township consists of an area of land 6 miles square and comprises 36 sections.*

   (a) How many miles around a section? Around a half-section? Quarter-section?

   (b) How many rods square is a quarter-section? How many rods long is half of a quarter-section?

   (c) How many rods long is a quarter of a quarter-section? Wide?

   (d) What part of a section is a 10-acre field?

2. A field measuring 20 × 80 rods contains how many acres?

   (a) A square field containing the same number of acres would be how long and how wide?

   (b) What is the difference in the number of rods around the two fields? How does this fact affect the fencing problem?

*36 sections may or may not be a town.

3. 450 cubic feet of settled hay make a ton. How many tons of hay in a settled mow $15 \times 30 \times 20$ feet?

4. When corn silage averages 40 pounds per cubic foot, how many cubic feet are required for one and one half tons?

5. When a map is drawn on a scale of "$\frac{1}{4}$ inch = one mile," how many miles between two cities when map measurement is $8\frac{1}{2}$ inches?

6. How long and how wide must a drawing be to represent a half-section when $\frac{1}{8}$ inch = 10 rods?

7. How many rods around 3 contiguous quarter-sections? Which costs the more to fence, $\frac{3}{4}$ of a section or a section?

8. What is the area of a circle whose diameter is 2 inches? (See page 61, Part I.)

9. How many paces in a mile?

10. How many paces on the end of a square ten-acre field are required to mark off one acre?

WRITTEN PROBLEMS

1. Draw a diagram representing a section of land. Use scale $\frac{1}{8}$ inch = 10 rods. (Review pages 33 and 34.)

   (a) Locate in this section the S $\frac{1}{2}$ of NE $\frac{1}{4}$; the SE $\frac{1}{4}$ of the NW $\frac{1}{4}$; and the NE $\frac{1}{4}$ of SW $\frac{1}{4}$ of the SW $\frac{1}{4}$. How many acres in each block of land?

2. Draw a diagram to represent a Congressional township. Use scale 1 inch = 2 miles.

   (a) Locate the S $\frac{1}{2}$ of Sec. 8; the NE $\frac{1}{4}$ of Sec. 24; the W $\frac{1}{2}$ of Sec. 32; the E $\frac{1}{2}$ of SE $\frac{1}{4}$ of Sec. 16.

3. Locate in another diagram drawn to the scale of $\frac{1}{2}$ inch = 6 miles, a township which lies in the fifth row north of the base line and in the third tier of townships east of the principal meridian.

(a) Locate in this township sections 8, 12, 15, 25 and 34.

(b) Describe the location of section 16 as to township (T) and range (R).

4. Using the same base line and principal meridian as in problem 3, locate T 6 N, R 5 E.

(a) Locate the W $\frac{1}{2}$ of Sec. 28.

5. In a diagram drawn to a scale of 1 inch = 6 miles, locate the NW $\frac{1}{4}$ and the S $\frac{1}{2}$ of Sec. 20, T 3 N, R 2 W.

6. Sketch an outline map of your state, use scale 1 inch = 48 miles, and locate the base line from which "T" is reckoned, and principal meridian from which "R" is determined.

(a) Locate T 4 N or S, R 3 E; T 5 N, R 4 W; T 6 S, R 7 E.

(b) In what counties in your state are these townships located?

(c) Locate the township in which you live. Describe the section in which you live, giving section, number, "T," and "R."

(d) Get the description of your farm, or one with which you are familiar. Locate it in the section or sections; within the township; range.

7. The sides of a triangular field measure 40 rods, 36 rods and 20 rods, respectively.

(a) Draw a diagram—scale $\frac{1}{4}$ inch = 2 rods, representing this field.

(b) Determine the number of acres in this field. (See page 57.)

8. Another triangular field has sides measuring 30, 20 and 20 rods, respectively.

(a) Draw a diagram of this field to a scale of $\frac{1}{2}$ inch = 5 rods.

(b) How many acres in this field?

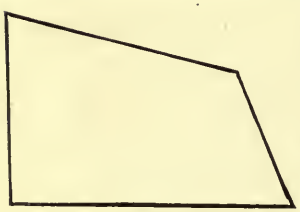

Figure 28.

9. Figure 28 represents an irregular field drawn to scale of $\frac{1}{4}$ inch = 5 rods.

(a) Draw a diagram of this field to the scale of 2 inches = 5 rods and determine the number of acres in it. (Page 31.)

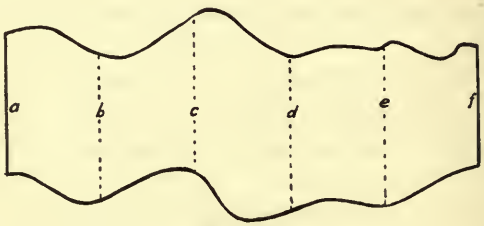

Figure 29.

The number of acres in a field having the shape of Figure 29 may be determined by measuring the breadth in rods in a number of places at equal distances apart, as a, b, c, d, e and f; add these measurements and find the average breadth; then multiply by average length in rods and divide by 160.

10. The length of a field similar in shape to Figure 29 having crooked and irregular sides measured 30 rods; the breadth at intervals of 3 rods measured 9, 12, 9, 6, 8, 12, 12, 8, 14, 9 and 12 rods, respectively.

(a) Draw a diagram of this field to a scale of $\frac{1}{2}$ inch = 3 rods.

(b) How many acres in this field?

(c) If a fence were to be built on the boundary of this field as you have drawn it, how many rods of fencing would be required to inclose it?

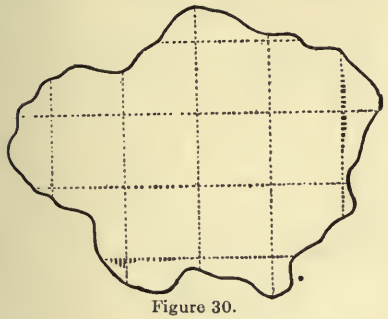

Figure 30.

11. Figure 30 is the outline of an island showing where and how measurements were made to determine its area. How many acres in the island? Diagram is drawn to scale of $\frac{1}{8}$ inch = 4 rods.

12. Figure 31 is an outline of a farm drawn to a scale of 1 inch = 40 rods. This farm represents the W $\frac{1}{2}$ and a part of the NE $\frac{1}{4}$ of the SE $\frac{1}{4}$ of Section 16, T 2, R 1 W.

(a) By measurement, determine the number of acres in each field.

(b) How many rods of fencing around each field? (No fence along water-front in field No. 8.)

(c) How many rods of fencing are required for the whole farm?

13. The following map, Figure 32, shows a tiling system a farmer put in one of his fields at an average cost of 47 cents per rod.

(a) Determine the total cost to tile this field.

(b) The first year after tiling, this field averaged 70 bushels of shelled corn per acre, which was a 95% increase over the average yield before tiling. When corn is worth 65 cents a bushel determine the per cent of net profits on cost of tiling for that year.

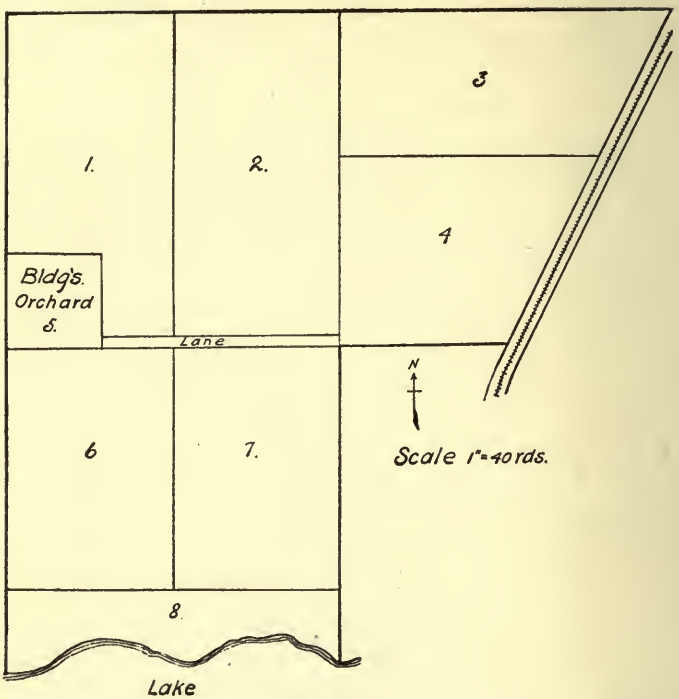

Figure 31.

14. A man had a silo 35 feet deep and 16 feet in diameter, as inside measurements, containing 15 feet of silage. Assuming the silage in the bottom five feet to weigh on an average 55 pounds per cubic foot, the second 5 feet, 51.4 pounds and the top 5 feet, 46 pounds per cubic foot, determine the amount and value of the silage at $3.50 per ton. (See page 61, on area of a circle.)

Measuring Hay:

To measure hay in mows: Volume ÷ 420 to 500 cubic feet = tons. 450 cubic feet of settled hay in a mow is

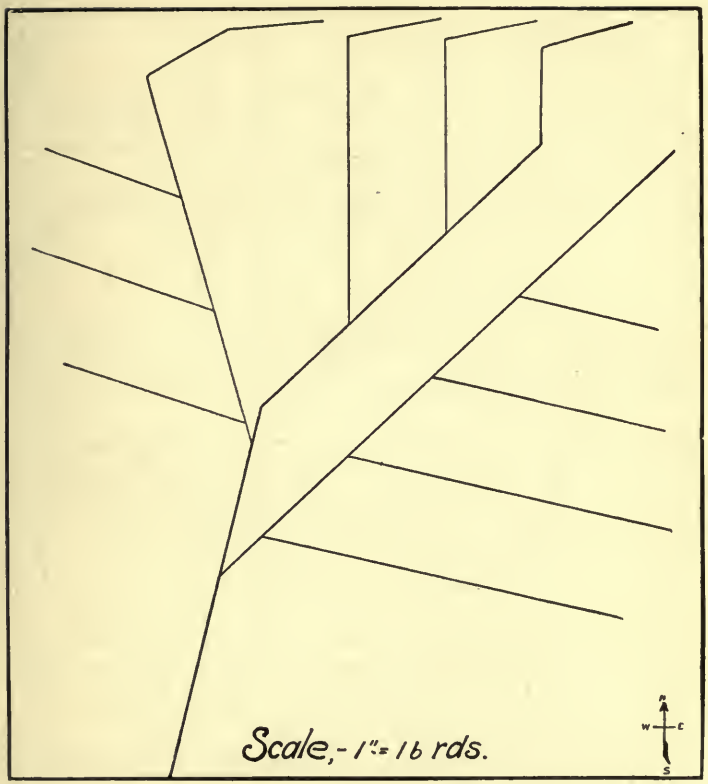

Figure 32.

commonly taken to equal a ton. For timothy use 420, for clover 500 cubic feet.

*To measure hay in ricks**: Volume of rick ÷ 515 to 590 cubic feet = tons. The volume (cubic feet) of a rick is determined by multiplying the cross-section of a rick by the length (*L*). The cross-section is obtained by multiplying the "over" (*O*), which is the distance from the ground on

*U. S. Dept. of Agriculture, Bureau of Plant Industry, Circular 131.

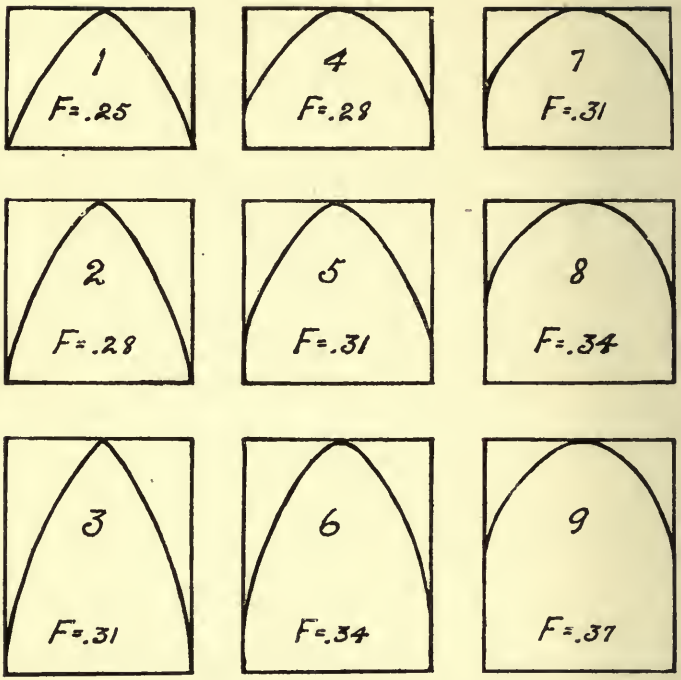

Figure 33. Cross-section of Hayricks of Different Shapes.

one side of the rick over the top of the rick to the ground on the other side, by the width (W), by a fraction (F), which varies from .25 to .37, depending upon the height and fullness of the rick. If the rick has a cross-section similar to 1, Figure 33, the fraction is .25; if like 9, it is .37. Therefore:

Volume (V), of rick = Fraction (F), $\times$ Over (O) $\times$ Width (W) $\times$ Length (L); or $V = FOWL$.

590 cubic feet of hay† in rick or stack standing less than 30 days = 1 ton.

†Mixture of clover and timothy.

580 cubic feet of hay in rick or stack standing from 30 to 60 days = 1 ton.

515 cubic feet of hay in rick or stack standing from 75 to 155 days = 1 ton.

15. A mow 18 feet wide and 36 feet long has 18 feet of settled mixed hay in it. How many tons of hay does it contain? How many tons if it were timothy? If it were clover?

16. A hayrick is 16 feet wide, 20 feet long, and the "over" is 30 feet. The end view indicates that the shape of the rick is very close to No. 5 in Figure 33. How many tons of hay in the rick when it has been standing about 50 days?

SOLUTION:

Volume (V) $\div$ 580 = tons. $V = FOWL$.

No. 5 in Figure 33 shows F equals .31. Therefore:

$$\frac{.31 \times 30 \times 16 \times 20}{580} = 5.13 \text{ tons.}$$

17. A hayrick measures 14 feet wide, 24 feet long, and the "over" is 34.2 feet. Inspection of the end of the rick shows that it is of the type of No. 8, Figure 33. The rick has been standing 5 months. Determine the value of the hay at $15 per ton.

18. A man bought a rick of hay for $65. After it had been standing for 3 weeks it measured 30 feet long, 11.5 feet wide, with an "over" of 33 feet. The end view of the rick showed that it was similar in shape to No. 6, Figure 33. What price per ton was paid for the hay?

19. The "over" of a hayrick which has been standing 5 months measures 34 feet, the length is 40 feet, and the width 16 feet. The end view of this rick indicates that it has the shape of No. 9 in Figure 33. How many tons of hay in the rick?

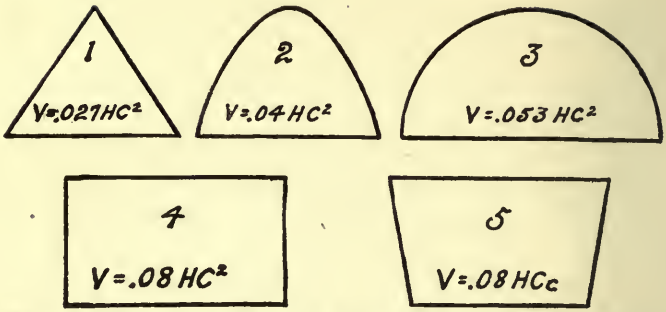

Figure 34.—Diagram showing various shapes of round haystacks. 1, 2 and 3 represent upper portions of stacks; 4 and 5, lower parts. V = volume, H = height of part of stack measured; C^2 = circumference squared; C_c = circumference at top of base, X circumference at bottom of stack.

To measure hay in round stacks: Volume (V) ÷ 515 to 590 cubic feet = tons.

Haystacks are built either with a cylindrical base and like outline No. 4, Figure 34, or like No. 5, Figure 34. Tops may be formed like Nos. 1, 2 and 3, Figure 34. It is necessary to determine the volume in cubic feet of the top and bottom parts separately and add them together. Formulas for determining volume (V) of the parts are given in the outlines in Figure 34. Read legend.

20. The base of a haystack is cylindrical and the top is like No. 1, Figure 34. The height of the base after standing 3 months, is 4 feet, and the height of the top is 6 feet, the circumference of base of stack is 30 feet. How many tons of hay in the stack?

SOLUTION:

Step 1. Top of stack (No. 1, Figure 34) $V = .027 \times 6 \times 30^2 = 145.8$ cubic feet.

Base of stack (No. 4, Figure 34) $V = .08 \times 4 \times 30^2 = 288.0$ cubic feet. Total 433.8 cubic feet.

Step 2. 433.8 ÷ 515 (page 195) = .84 ton.

21. A haystack has a base of the shape of outline No. 5, Figure 34, and a top similar in shape to No. 2, Figure 34. The height of the top, after standing 4 months, is 6 feet,

the circumference at the bulge is 48 feet, the height of base is $5\frac{1}{2}$ feet, and the circumference at the bottom of the stack is 40 feet. Determine the number of tons of hay in the stack?

SOLUTION:

Step 1. Top of stack (No. 2, Figure 34) $V = .04 \times 6 \times 48^2 = 552.9$ cubic feet.

Base of stack (No. 5, Figure 34) $V = .08 \times 5\frac{1}{2} \times 48 \times 40 = 844.8$ cubic feet. Total, 1,397.7 cubic feet.

Step 2. 1,397.7 ÷ 515 (page 195) = 2.7 tons.

22. The base of a haystack is like No. 4, Figure 34, and the top like No. 2, Figure 34. After standing about 3 weeks, the height of the top portion measured 15 feet, the circumference of the base measured 50.5 feet, and the height of the base 12 feet. What is the stack worth at $12 per ton?

23. A haystack standing about 2 months had a base 10 feet high the shape of No. 5, Figure 34, measuring 60 feet at the bulge and 51 feet at the bottom of the stack. The top shaped like No. 1, Figure 34, was 11 feet high. The stack was sold for $54. At what price per ton was the hay sold?

To determine bushels of grain, apples, corn, etc., in bins:

To determine bushels (not heaped) of grain in bin, divide cubic content in inches by 2,150.4. For quick calculation let 1.2 cubic feet = 1 bushel.

To determine bushels (heaped measure) of apples, potatoes, ear corn, etc., in bins, divide cubic content in inches by 2,747.7. (Let 1.6 cubic feet = 1 heaped bushel for quick calculation.) Deduct $\frac{1}{3}$ from heaped bushels for bushels of shelled corn. (56 lbs.)

24. How many bushels of wheat will a bin 20′ × 20′ × 10′ level full hold?

25. An old, circular water-tank 15 feet in diameter and 12 feet high (inside measurements) will hold how many bushels of barley when level full? How does the weight of this volume of barley compare with that of water?

26. A bin 9′ × 9′ × 8′ level full of oats was sold for $20 per ton. How many bushels were sold and how much per bushel was received for them?

27. How many bushels of potatoes in a bin 20′ × 30′ × 6′ level full?

28. A crib 30 feet long, 8 feet wide, and 8 feet high is $\frac{2}{3}$ full of ear corn. When shelled corn is worth 74 cents per bushel, determine the value of the corn in the crib.

29. How many heaped bushels of ear corn are contained in a crib with flared sides 25 feet long, 8 feet high, 6 feet wide at the bottom* and 9 feet wide at the top, when level full? Equivalent in shelled corn?

30. A man built a circular cement tank 16 feet in diameter and 3 feet deep (inside measurements). How many barrels of water would this tank hold when full.

31. How many gallons in one cubic foot of water?

32. A man wanted to build a cement tank 2 feet deep and 12 feet long (inside measurements), to hold 50 barrels of water when full. How wide must it be (inside measurement)?

33. A farmer had a field of acid soil 16 × 20 rods. He planned to apply lump-lime to the plowed land at the rate of 1 ton per acre. When 50 pounds of the lime are to be placed in each pile, how far apart must the piles be placed?

(a) Draw a diagram of this field on the scale of $\frac{1}{4}$ inch = 2 rods, and show the position of the piles in the field.

(b) When lump-lime increases 80 per cent in weight on air-slaking, determine the amount of air-slaked lime in each pile.

(c) Over how many square rods must the contents of each pile be spread?

*Average width = ½ sum of top and bottom widths.

34. Having no tape, a man measured the length and width of a potato patch by counting the revolutions made by the fore wheel of his buggy. He found the measurements to be 60 and 22 revolutions, respectively. The wheel measured 3 feet 4 inches in diameter. How many acres in the potato patch?

35. A drive-pulley 4 feet in diameter must make how many revolutions per minute to give a speed of 1884 revolutions per minute to a shaft-pulley 8 inches in diameter?

36. How many bushels of oats will a bin $10 \times 9 \times 8$ feet hold when full? How many tons of oats? Tons of barley? Tons of wheat?

Concrete Work:

37. When 1 part of cement is to be mixed with 2 parts of sand and 4 parts of gravel or crushed stone (a 1:2:4 concrete mixture), give the number of shovelfuls of sand and cement that must be added to 20 shovelfuls of gravel to make this mixture.

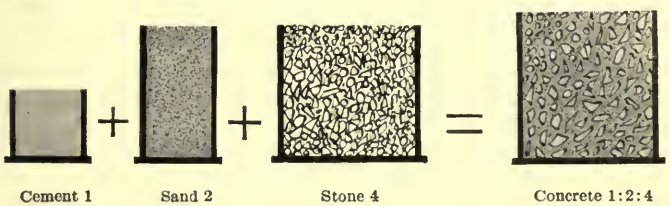

Figure 35.—Comparative Amounts of Ingredients for a 1:2:4 Concrete Mixture. The volume of concrete resulting from the mixture is slightly greater than that of the stone. The cement and sand completely fill the open spaces in between the stone particles.

38. One bag of cement is equal to about $\frac{7}{8}$ of a cubic foot. How many cubic feet of sand and gravel must be used for a 2-bag batch 1 : 2 : 4 concrete mixture? For a 4-bag batch 1 : 3 : 6 mixture?

39. When 1 barrel* of cement is regarded as equal to 3.8 cubic feet, how many cubic feet of sand and crushed stone must be used to make a 1: 3: 6 concrete mixture?

Ingredients in one cubic yard of concrete.†

Proportion by vol.	1 : 2 : 4	1 : 2½ : 4½	1 : 2 : 5	1 : 2½ : 5	1 : 3 : 5	1 : 3 : 6
Bbls. cement (1 bbl. = 3.8 cu. ft.)	1.46	1.32	1.25	1.20	1.13	1.00
Cubic yards sand	.41	.46	.35	.42	.48	.42
Cubic yards gravel or stone	.82	.83	.88	.84	.80	.84

40. By consulting the table, determine the amount of cement, sand and gravel necessary to construct a wall 30′ × 8′ × 10″ when a 1: 2½: 5 concrete mixture is used.

41. How many barrels of cement, and cubic yards of sand and gravel are required to construct a foundation for a house 34′ × 30′? The foundation is to be 9 feet high on all sides and 10 inches thick. An impervious wall is desired; hence a 1: 2 : 4 cement mixture‡ is to be used.

42. Determine the amount of material required to fill 10 iron pipes (for end fence-posts) 8 feet long and 6 inches in diameter (inside measurement), when a 1: 2½: 5 mixture is used.

43. A man wishes to build a concrete silo large enough to supply silage for his herd of 25 cows to be fed on an average of 35 pounds daily for 9 months. When settled silage averages 42 pounds per cubic foot, how large a silo must he build? (See footnote page 97.)

*4 bags cement are usually equal to a barrel.

†From Popular Handbook for Cement and Concrete Users, Lewis & Chandler.

‡A perfect concrete mixture contains enough cement to fill the empty spaces in between the sand particles, and coat each grain, while the sand with its coating of cement fills the voids in the aggregate and also covers each stone with a film of mortar.

(a) When 6 feet of the silo is to be a stone foundation, determine the concrete material required to construct the portion above the stone foundation, wall to be 6 inches thick, and a 1: 2: 4 mixture used. Determine the cost of this material at local prices.

Do you know:

1. How many acres in a section?
2. How many cubic feet of hay equals a ton?
3. A formula to determine the area of a circle?
4. The meaning of range (R), and township (T), in land description?
5. How to determine bushels of grain or ear corn in a bin?
6. What a 1 : 3 : 5 concrete mixture means?

CHAPTER XIII

ORCHARD AND GARDEN

The fruit-growing industry thrives best in certain geographical areas, since climate is the chief determinative factor. Home-grown fruits, however, can be made the rule in humid climates rather than the exception when proper attention is given to location, planting, varieties, pruning and spraying. The farmer's orchard and garden are often objects of disgrace rather than sources of profit. It has been demonstrated that the expense for labor in caring for a garden large enough to supply the needs of an average family need not exceed $30 per year*, and the retail value of the vegetables which may be grown in a carefully planned and well-kept garden greatly exceeds the cost to produce them.

ORAL PROBLEMS

1. How many cherry trees on 7 acres, when 170 are planted per acre? When 239 are planted per acre?

2. How many apple trees on 9 acres, when 48 trees is the average per acre? On 12 acres, when 84 are planted per acre?

3. How many plum trees on eleven acres, when 196 are planted per acre? When 239 are planted per acre?

4. When 60.8 barrels of apples, on an average, were harvested from half an acre, how many barrels from 5 acres? From 7 acres?

*Illinois Agricultural Experiment Station, Bulletin 105.

5. When 96.8 barrels of apples were raised per acre at a cost of 90 cents per barrel, what was the total cost per acre?

(a) When the apples were sold for $2.90 per barrel, what were the total net profits per acre?

6. When it cost, on an average, $3.80 per acre to spray an orchard, what did it cost for $5\frac{1}{2}$ acres?

7. In a test made in New York, a part of an orchard kept in sod produced 69.2 barrels of apples per acre as an average for 10 years, while 116.8 barrels were harvested per acre from a tilled portion. What was the increase in yield due to tillage?

(a) $126.04 was secured as average annual gross returns per acre from the sod portion, and $224.15 per acre from the tilled portion. What was the difference in receipts in favor of tillage?

(b) The average acre-cost of growing the apples on sod was $51.73, and under tillage, $83.48. What were the net profits in each case? Increase in net profits due to tillage?

8. 16 bushels of potatoes were harvested from a garden plat 2 rods by 4 rods. At this rate what would an acre yield?

9. When a crate of strawberries (16 quarts) sells for $1.92, what is the selling price per quart?

10. An acre of strawberries yielding 5,120 quarts produces how many bushels?

11. Twelve tomato plants, occupying one square rod in a garden, yielded 7 bushels of tomatoes. At this rate what would the yield per acre be? Pounds per acre?

12. A small garden plat of potatoes sprayed for blight yielded 21 bushels, while an equal area not sprayed produced 12 bushels. What was the per cent increase in yield due to spraying?

13. According to U. S. statistics, the average cost to grow an acre of tomatoes in the South for the canning factory is as follows: $5 for land rental, $3.50 for plowing and fitting the land, $2.25 for cost of plants, $7 for cost of fertilizers, $1.50 for setting the plants, $3 for cultivation, $8 for picking and $10 for hauling to factory. Determine total cost.

(a) When tomatoes yield 200 bushels per acre and average $12 per ton, what are the receipts per acre? Net profits? (60 lbs. per bushel.)

WRITTEN PROBLEMS

1. When pear trees are planted from 20 to 30 feet each way; plums and peaches from 16 to 20 feet each way; and cherries from 16 to 25 feet each way, how many trees of each kind can be planted on an acre?

2. When apple trees are planted 36 feet apart each way, according to the rectangular system of planting, how many trees can be planted per acre?

(a) Draw a diagram to a scale of $\frac{1}{2}$ inch = 36 feet, representing a square plat large enough to accommodate 36 trees according to this system of planting. Place a dot for each tree, and place no trees on the boundary lines.

3. If, in problem 2, a tree were planted in the center of each square, how many more trees would the small plat contain?

(a) Draw a diagram, as in problem 2 (a), to illustrate this system of planting which is called the *quincunx* system.

(b) How many apple trees could be planted per acre in problem 2, according to this system, when in actual practice about 75% more trees can be planted per acre?

4. When apple trees are planted, according to the rectangular system, 33 feet each way, how many trees can be planted per acre. How many per acre according to the quincunx system?

5. Draw a diagram the same size and to the same scale as in problem 2 (*a*), and place the trees 36 feet apart each way in three directions. How many more trees can be placed on this plat than when they are placed according to the rectangular system of planting?

(a) This system of planting is called the hexagonal system and gives about 15% more trees per acre than the rectangular system. Can you determine why this is called the hexagonal system?

(b) Determine the distance between the rows.

6. When young prune trees are planted $16\frac{1}{2}$ feet apart each way, how many are planted per acre, according to the rectangular system? According to the quincunx system? According to the hexagonal system?

7. Determine the amount of each material required to make 350 gallons of Bordeaux mixture* to be used as a fungicide in spraying an orchard.

**Bordeaux Mixture* for orchard is made as follows, according to one of the methods: Dissolve 4 pounds of blue vitriol (copper sulphate) in 10 gallons of water in a wooden or earthen vessel. In another vessel slake 4 pounds of good, fresh quicklime in 10 gallons of water. Add enough water to make 25 gallons of each solution. When mixture is wanted pour the blue vitriol solution and the milk of lime slowly and at the same time into a barrel, stirring all the time.

8. 360 gallons of kerosene emulsion† are to be used for scale insects and plant lice. Determine the amount of material required to make this amount for summer spraying. For winter spraying.

9. In West Virginia an orchard consisting of 600 trees and neglected for 17 years became almost obscure by growth of brush and saplings. The new owner had it rejuvenated. The total expenses and receipts for the first three years were as follows:

EXPENSE

Cost of trimming and clearing up land averaged $16\frac{2}{3}$ cents per tree.

200 loads of manure and straw at 75 cents per load.

Cost of picking and hauling apples averaged 25 cents per tree.

Cost of 833 barrels at 37 cents.

RECEIPTS

1st year: Cash for sale of fruit..... $ 400.00
2nd year: No crop.....
3rd year: Cash for sale of fruit..... 1,431.75

(a) Determine the total expenses for the three years.

(b) Determine the total net profits from this rejuvenated orchard during the first three years.

(c) What was the average annual cost per tree? Average yearly net profits? (Interest on investment not included in cost.)

† *Kerosene Emulsion*: Dissolve ½ pound common hard soap in one gallon of hot water, add 2 gallons of kerosene and churn together until a white creamy mass is formed which thickens on cooling. For summer spraying dilute to 27 gallons and for winter spraying, dilute to about 13 gallons before using.

(d) If the trees covered 10 acres of land valued at $300, what was the interest realized on the investment for the three years? If land value was $85 per acre?

10. In New York* an account was kept with an apple orchard for 10 years to determine profits. The annual yield of fruit from this orchard for 10 years was as follows:

Year	Per tree			Per acre		
	Barreled apples	Culls and drops	Total yield	Barreled apples	Culls and drops	Total yield
1904	2.45	2.13	.....	66.53	58.08	.....
1905	1.42	0.74	.....	38.59	20.12	.....
1906	2.67	1.44	.....	72.69	39.12	.....
1907	2.41	0.88	.....	65.53	23.79	.....
1908	4.18	1.41	.....	113.85	38.25	.....
1909	2.37	1.64	.....	64.63	44.57	.....
1910	1.92	0.69	.....	52.21	18.80	.....
1911	3.41	2.19	.....	92.84	59.60	.....
1912	3.86	1.70	.....	105.05	46.17	.....
1913	4.41	1.02	.....	120.00	27.62	.....
Total	.....	.....	.....	.....	.....	.....
10 yr. av.	.....	.....	.....	.....	.....	.....

(a) Determine the total yield of apples per tree and per acre for each year.

(b) Determine the production of (1) barreled apples, (2) culls and drops, and (3) total, for ten years, per tree and per acre. Determine the 10-year averages.

(c) The barreled apples were sold for an average of $2.61 per barrel, and the culls and drops for an average of 72 cents per barrel. What were the average annual receipts per tree? Per acre?

*New York, Geneva Bulletin 376.

11. The average cost to grow and harvest a barrel of apples in problem 10 was as follows:

Interest on investment at 5%	21.4	cents
Taxes	1.2	cents
Tillage	6.3	cents
Pruning	3.0	cents
Spraying	9.6	cents
Cover crops	2.3	cents
Superintending orchard	25.0	cents
Picking, packing, sorting, hauling	24.4	cents

Note: All work was hired done, and workmen furnished their own teams and tools.

(a) What was the total cost to grow and harvest a barrel of apples? Cost per acre?

(b) The cost of barrels averaged 36 cents, and the culls and drops were sold without being barreled. Determine the average yearly net profits per tree. Per acre.

(c) What was the average 10-year net income received per acre from this orchard? What was the annual per cent interest received on the investment?

12. How much seed potatoes would be required to plant a garden patch 2.5 by 6.4 rods, when ordinary planting requires about 12 bushels per acre, and these are to be planted $\frac{1}{3}$ thicker than ordinary planting?

(a) The potatoes are to be treated for scab. One pound ($\frac{1}{2}$ quart) of formalin will make 30 gallons of disinfecting solution,* which is enough to treat 50 bushels of potatoes. Determine the amount of formalin and formalin solution required to treat these potatoes.

(b) How much Paris green† would be required for each application to kill potato beetles

*The whole potatoes should be soaked 2 hours in the formalin solution, and the seed should be planted within two or three days after treatment.

†Paris green may also be applied with Bordeaux mixture.

when one pound of Paris green with 3 pounds of lime in 50 gallons of water is sufficient for one acre? How much lime? How much water?

(c) When 5 gallons of Bordeaux mixture are required on this patch for one spraying for blight, determine the amount of material required.† Write out the full directions for making this amount of Bordeaux mixture. (See footnote.)

13. A country boy moving to town started a garden on a vacant lot. He agreed to pay the taxes for the privilege of selling all crops grown. He raised and sold the following.

30 lbs. of wax beans at 8c. per lb.; ½ bu. late carrots at 50c. per bu.; 140 bunches celery at 5c. per bunch; 1,400 small cucumbers at 25c. per hundred; 500 medium sized cucumbers at 35c. per hundred; 36 large cucumbers at 8c.; 25 bunches of green onions at 6c.; 3 bu. onions at 3c. per lb.; 93 lbs. peas averaging 9c.; 35 bunches radishes at 5c.; 72 bunches salsify at 6c.; 2½ bu. parsnips at 50c. per bu.; 186 green peppers at 25c. per doz.; 150 lbs. early potatoes averaging 2.1c. per lb.; 660 lbs. late potatoes at 75c. per bu.; 32.5 lbs. string beans at 10c.; 30 summer squash at 5c.; 5 hubbard squash at 15c.; 35 doz. ears sweet corn at 16c. per doz.; 8 bu. tomatoes averaging 2.1c. per lb.

(a) Determine gross receipts.

(b) Taxes were $26.05; plowing, $1.25; garden tools, $3.15; seeds, $2.46; miscellaneous, 96c. What were the net profits?

(c) What part of an acre did the boy have in garden when the patch was 3⅓ by 6 rods.

†Bordeaux mixture for potatoes should be made by using 5 pounds each of blue vitriol and quicklime. (See footnote, page 207).

(d) His late potatoes occupied a plat 1.2×4.17 rods. At what rate did the potatoes yield per acre? (Solve by proportion.)

(e) The onions were planted in two rows 70 feet long and 16 inches apart. What would the yield have been had there been an acre of such onions? Returns per acre, if sold at 2.5 cents per pound?

Before beginning the next chapter, mention 10 facts of practical value you have learned in working the problems in Chapter XIII.

CHAPTER XIV

HOUSEHOLD ECONOMY AND HUMAN FEEDING

The feeding of stock has long been reduced to a science, but scientific human feeding has only recently received much attention from the average housekeeper. The demands of the human body are properly met only when the right kind and amount of food are supplied. To this end an understanding of the basic principles of nutrition is necessary, together with the relative nutritive values of foods. The right food in right amounts for the least cost must be the slogan of the efficient housekeeper.

ORAL PROBLEMS

1. When 2 cupfuls of milk are equivalent to one pint, one and one half cupfuls is what part of a pint? What part of a quart? Gallon?

2. When 36 cents per dozen is paid for eggs and 3 out of a dozen on an average are bad, what is the real price paid per dozen for good eggs?

3. 8 to 10 hen eggs are equivalent to a pound. What are 10 dozen eggs worth at 20 cents per pound?

4. A tablespoon level full of butter contains one half an ounce. How many tablespoonfuls of butter in 4 pounds?

5. Three teaspoonfuls of liquid equals 1 tablespoonful, and 1 tablespoonful equals one half an ounce. How many teaspoonfuls in 5 pounds of water?

6. The net weight of a 50-pound sack of flour is 49 pounds. When about 3 cupfuls of flour are required for a loaf of bread, how many loaves ought a sack of flour to make? (4 cupfuls of flour = 1 pound.) Value at 5 cents per loaf?

7. When bacon costs 30 cents per pound, and $66\frac{2}{3}$ of its weight is lost in cooking, what is the cost per pound of the portion eaten?

8. When round steak costs 22 cents per pound and about 2% is lost in cooking, what is the cost of the portion consumed?

9. When round steak containing 18.4% digestible protein can be purchased for 20 cents per pound, and bacon containing 8.8% protein for 25 cents, how much protein can be purchased for one dollar in each case?

10. Whole milk contains 3.2% digestible protein, and dried beef 25.6%. How much dried beef is equivalent to one quart of milk (2 pounds) in protein value?

11. Dried white beans contain 2.6% digestible mineral matter (ash) and 17.5% digestible protein; apples contain only 0.2% ash and 0.3% digestible protein. How many pounds of apples are equivalent to 2 pounds of beans in supplying digestible mineral matter? In supplying protein? Of what value is ash and protein in nutrition? (See page 237.)

12. Cheddar cheese contains 27.7% protein and 36.8% fat. Fresh pork (shoulder) 12% protein and 29.8% fat. When cheese can be purchased at 18 cents per pound and pork at 22 cents which is the more economical food from standpoint of nutrients contained? From standpoint of preparation?

WRITTEN PROBLEMS

1. According to U. S. investigators, the average annual value of the food purchased and consumed by the average farm* was $150.74; and that which was furnished by the farm was valued at $261.35.

*In the southern states the value of food products furnished by the farm is appreciably higher than in the northern states, owing to the long growing season for vegetables, and to the fact that more meat is furnished by the farm for home consumption. U. S. Farmers' Bulletin, No. 635.

(a) What per cent of the total value of the food consumed by the average family was purchased? Furnished by the farm?

(b) The average size of the families in this investigation was 4.6 persons. What was the annual consumption of food per person?

(c) It was further found that the yearly cost of food per person in families of two and three averaged $108; and in families of six persons and over, $80. What per cent less was the food-cost per person in the larger families than in the smaller families? What per cent greater was the food-cost per person in the smaller families than in the larger?

2. When 1.1 pounds of a 4-pound chicken is refuse (bones, head, etc.) what greater per cent of edible portion is obtained when a $5\frac{1}{2}$-pound chicken is purchased? (Assume same amount of refuse.)

3. When ribs (beef) are purchased at 22 cents per pound, and 20.8% is refuse, what is the price paid per pound for the edible portion?

4. When round steak (medium) is purchased at 22 cents per pound, and 7.2% of it is refuse, what is the price paid per pound for the edible portion?

5. Determine the material and total cost of making 6 loaves of slow process bread when the following recipe is used:

3 cupfuls scalded milk
3 cupfuls cold water
3 tablespoonfuls sugar
About 18 or $19\frac{1}{2}$ cupfuls flour
3 tablespoonfuls lard
3 teaspoonfuls salt
$\frac{3}{4}$ cake compressed yeast
$\frac{3}{4}$ cupful lukewarm water

Note: Consult table, page 246, for household weights and measures.

6. Determine the material and total cost in making a one-crust lemon pie when the following recipe is used:

1 cupful of sugar
2 egg yolks
3 tablespoonfuls of corn starch
4 tablespoonfuls of lemon juice, grated rind of one lemon
1 teaspoonful of butter
1 cupful of boiling water

FROSTING (Meringue)

2 egg whites
2 tablespoonfuls of powdered sugar
½ teaspoonful of lemon juice
¼ teaspoonful of vanilla

7. Determine the material and total cost of making a Spanish chocolate layer cake, as follows:

½ cupful of butter
1½ cupfuls of sugar
4 eggs
½ cupful of milk
1 teaspoonful of vanilla
2 squares of bitter chocolate
5 tablespoonfuls of boiling water
1¾ scant cupfuls of flour
4 teaspoonfuls baking powder

CARAMEL FILLING

2 cupfuls of dark brown sugar
1 cupful of white sugar
½ cupful of cream
½ cupful of butter
1 cupful of hot water

8. When 20 pounds of fish (mackerel) may be had at 15 cents per pound, determine the amount of edible portion purchased. (Table on page 237.)

(a) Determine real cost of edible portion.

9. If each person in a family of 6 averages 10 ounces of potatoes (edible portion) per day, how many bushels would be consumed in 3 months?

10. Ten bushels of tomatoes contain how many gallons of water? (60 pounds = 1 bushel of tomatoes.)

11. Determine the total amount of edible portion and digestible nutrients (protein, carbohydrates and fat) in 25 pounds of cabbage.

SOLUTION:

Step 1:

15% of the cabbage is refuse, hence 85% is edible.
$.85 \times 25$ lbs. = 21.25 lbs. edible portion in 25 lbs.

Step 2:
.012 × 25 lbs. = .3 lb. digestible protein.
.046 × 25 lbs. = 1.15 lb. digestible carbohydrates.
.002 × 25 lbs. = .05 lb. digestible fat.
1.50 lbs. total digestible nutrients.

12. Determine the total amount of digestible nutrients (protein, carbohydrates and fat) contained in 6 pounds of canned salmon, 15 pounds of cabbage and 12 pounds of butter. (Table, page 237.)

13. Compare the total amount of digestible nutrients contained in 25 pounds each of apples and bananas. At local prices, which fruit will furnish the greater amount of nutrients for one dollar?

14. A housewife purchased 8 dozen eggs at 20 cents per dozen. Would she have purchased more digestible nutrients had she invested the same amount of money in beef (shoulder) at 16 cents per pound? Determine the difference.

15. Which food will give the most digestible nutrients for $2, and how much more: veal (shoulder) at 18 cents, beef (neck) at 14 cents, or limburger cheese at 20 cents per pound?

16. Nine eggs (1 pound) are equivalent in digestible nutrients to how many pounds of bananas?

SOLUTION:

Step 1:
.127 × 16 oz. = 2.03 oz. digestible protein.
.088 × 16 oz. = 1.41 oz. digestible fat.
3.44 oz. = total digestible nutrients in 1 lb. of eggs.

Step 2:
.007 × 16 oz. = .112 oz. digestible protein.
.129 × 16 oz. = 2.064 oz. digestible carbohydrates.
.004 × 16 oz. = .064 oz. digestible fat.
2.24 oz. total digestible nutrients in 1 lb. of bananas.

Step 3

Since 1 lb. of eggs contains 3.44 oz. of digestible nutrients and bananas 2.24 oz., 1 lb. of eggs is equivalent to 1.5 lbs. of bananas in total nutrients. $(3.44 \div 2.24 = 1.5+)$

17. One quart of whole milk (2 pounds) is equivalent in total digestible nutrients to how many pounds or ounces of eggs, cheddar cheese, ham (fresh), peanuts, potatoes, apples and wheat bread?

(a) At local prices determine the cost of the quart of milk and the equivalents of the other foods.

Dietary Standards — Daily Requirements.

Age and Work Performed	Digestible Nutrients, Pounds			Nutritive Ratio
	Protein	Carbohydrates	Fat	
Children 6-15 years (average)..	0.16	0.71	0.10	1 : 5.2
Boy 14-16 years.....	0.22	1.00	0.1	1 : 5.5
Girl 14-16 years.....	0.19	0.89	0.09	1 : 5.7
Man, light muscular work (Atwater)..	0.22	0.77	0.22	1 : 5.7
Man, moderate work (Atwater)	0.28	0.99	0.28	1 : 5.8
Man, hard work (Atwater)....	0.39	1.43	0.55	1 : 6.9

18. What per cent greater amount of nutrients does a man at hard muscular work require than one at light work? A boy than a girl?

19. In one day a boy 15 years old ate 2 ounces of grape-nuts, 1 pound of wheat bread, 1 quart of whole milk, 5 tablespoonfuls of granulated sugar and $\frac{1}{8}$ of a pound of butter.

(a) Determine the amounts of digestible protein, carbohydrates and fat in each food eaten. Total amounts.

(b) Did the boy eat enough to satisfy his requirements? Explain.

20. What per cent more digestible protein and ash has whole wheat bread that white bread?

21. What per cent more digestible fat is contained in Brazil nuts than in tenderloin?

22. A bowl of bread-and-milk consisting of a pint of milk and 4 ounces of wheat bread is equivalent in total nutrients to how many ounces of "grape-nuts" with 2 tablespoonfuls of sugar (granulated) and 6 ounces of cream?

(a) Are "grape-nuts" as nourishing as you supposed they were? Compare the cost of these two dishes when milk costs 7 cents per quart, bread 5 cents per loaf (1 pound), sugar 6 cents, cream 30 cents per quart, and "grape-nuts" 12.4 cents per pound. If an ounce of "grape-nuts" is eaten, what would you suggest in addition to equal food value of the bread-and-milk?

23. Of the common foods mentioned in table, page 237, which will give the greatest amount of digestible protein for one dollar at local prices? The greatest amount of carbohydrates? The greatest amount of fat? The greatest amount of total nutrients? The greatest amount of mineral matter (ash), excepting the salted articles?

24.

Daily Ration No. 1.	*Daily Ration No. 2.*
1½ lbs. of potatoes*	1 lb. of potatoes
⅛ lb. of rice	1½ lbs. of wheat bread
1½ lbs. of wheat bread	⅛ lb. of cheese (cheddar)
⅓ lb. of butter	2 oz. of dried beef
¼ lb. of sugar (gran.)	¾ lb. of pork chops
¼ lb. of cornmeal (corn cake)	3 tablespoonfuls of sugar (gran.)
¾ qt. of whole milk	¾ qt. of milk (whole)
½ lb. of pork chops	⅓ lb. of butter
¼ lb. of apricots	¼ lb. of cabbage
½ lb. of macaroni	¼ lb. of apricots
	3 oz. of white beans
	¼ lb. of bananas

Note: Pupils can work in pairs or groups of four on long problems like these.

*All amounts refer to digestible portion.

(a) Determine the amounts of digestible protein, carbohydrates and fat in each article in the two rations.

(b) Determine the total amounts of digestible nutrients in each ration.

(c) Determine the nutritive ratio of each ration.

(d) Which is the better ration for a man at hard work? Explain. Suggest ways of improving ration No. 1.

(e) Determine the amount of digestible mineral matter in each ration.

25. Make a list of 15 foods (salted foods excepted), containing comparatively large amounts of mineral matter (ash). Should we give much attention to the ash content of the foods we eat? What is "rickets"?

Important Facts:

1. The most desirable foods are those which furnish the most easily digestible nutrients at least cost.

2. Beans, peas and oat meal are rich in protein and are, therefore, especially valuable foods.

3. Proper cooking renders foods more digestible.

4. An individual should eat foods adapted to his peculiar requirements, and should avoid those that do not "agree" with him.

5. Too much food is as bad as too little.

CHAPTER XV

MISCELLANEOUS PROBLEMS

1. The ground floor in a round barn measures 50 feet in diameter. An 18-foot silo (19 feet outside measure) is in the center. How many square feet are used for stalls, walks and feeding space?

2. A man paid \$57.16 taxes on land including the W $\frac{1}{2}$ of the SW $\frac{1}{4}$ (valued at \$56.25 per acre) and the NE $\frac{1}{4}$ of the SW $\frac{1}{4}$ (valued at \$45), Sec. 15, T 5 N, R 19 E.

(a) What rate of taxes did he pay?

(b) Draw a diagram showing the location of this land within the section, location of section in township and relation of township with reference to base line and principal meridian.

3. Mr. Doe paid \$27 taxes on a vacant city lot 60′ × 120′. The rate was $1\frac{1}{2}$ cents on a dollar. Determine the valuation of the lot.

(a) What would the taxes be on an acre of such lots?

4. Corn is planted in hills 3 feet 8 inches apart each way in a square 10-acre field. How long is the longest diagonal row?

Figure 36.—Types of Milk Pails. Courtesy of Wis. Agr'l Exp. Sta.

(a) If the corn were planted in a field 20 rods × 80 rods, how long would be the longest diagonal row?

5. Bergy determined that milk from the udder averages 400 bacteria per cubic centimeter (1 c.c. = .061 cubic inch). After passing the strainer it contains 60,000 per c.c. How many times more bacteria in the strained milk than that from the udder? What per cent greater?

6. Milk from an ordinary cleanly, carefully kept cow may have no more than from 10,000 to 50,000* bacteria per c.c. at the outset; but this milk, carelessly handled, may, in

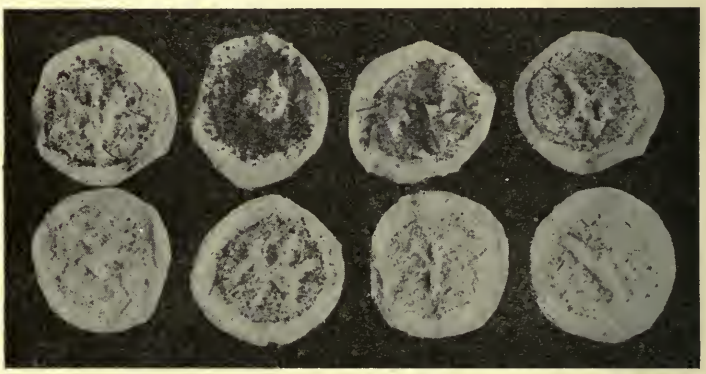

Figure 37.—Sediment From Open and Small-Top Pails. The open pail is a good dirt catcher in the hands of careless milkers. This explains in part why some milk is not good. Courtesy of Wis. Agr'l Exp. Sta.

the course of one or two days, have numbers as high as 100,000,000 per c.c. Determine the possible increase per minute in the number of bacteria per c.c. of milk.

7. Draw a diagram of your school grounds, to some convenient scale showing buildings, etc.

8. A farmer applied 1,000 pounds of rock phosphate, containing 13.5% phosphorus, to an acre of silt loam analyz-

*There is plenty of room in milk for these many minute organisms, when we consider that a space the size of a pin head may hold 8,000,000,000 of them.

ing .04% phosphorus (*P*). How much increase was made in the per cent of phosphorus in the soil? (See problem 2, page 120.)

9. A man sold $3,200 worth of fruit from 12 acres of orchard. Each dollar he received for the fruit cost him 40 cents. What were his total net profits? Profits per acre?

10. A farmer finding that his fanning-mill blew away half of his oats, decided to feed the oats to his horses without fanning them. He fed the usual allowance of 12 quarts per horse per day. Out of how many pounds of digestible nutrients did he cheat each horse per day?

Figure 38.—A Good Start for a Future Agriculturist. This boy has an ambition which will not only affect his pigs, but will some day extend to the broad fields around him. Courtesy of Country Gentleman.

11. Suppose the boy in Figure 38 sells his two pigs when they average 200 pounds and succeeds in "making" pork at the rate of 10 pounds per bushel of corn. How many bushels of corn would he feed when each pig gains 75 pounds?

(a) When the pigs cost him 6 cents per pound at the beginning of the feeding, and he receives $7.50 per hundred, determine his profits.

(b) The corn he fed was his own raising from a strip 4 rods × 7.4 rods. At what rate did his corn yield per acre, if he sold the pigs when his corn gave out?

(c) What would be his gross income resulting from the raising of corn and the feeding of it? At this rate what would the receipts be on the basis of an acre?

(d) Would he have done better had he sold his corn at 65 cents per bushel? What would he realize per bushel in feeding it to his pigs?

12. Write out a formula for making one gallon of kerosene emulsion. (See footnote, page 208.)

13. Write out a formula for making 10 gallons of Bordeaux mixture. (See footnote, page 207.)

14. It costs about 12 cents to set a fence-post and put on two or three wires. The average life of untreated cottonwood is 4 years. When the original cost per post is 6 cents determine the total cost of setting and renewals per post for 20 years. Determine the cost of setting and maintaining a mile of fence for 20 years. Posts set a rod apart.

(a) These posts can be made to last the 20 years, if treated at a cost of 15 cents per post. Determine the saving.

15. The following is a bill of lumber for a certified dairy barn in Kentucky:

34 sills	$6 \times 8 \times 12\frac{1}{2}$	40 joists	$2 \times 8 \times 10$
20 posts	$5 \times 5 \times 12$	80 joists	$2 \times 8 \times 12$
12 posts	$6 \times 6 \times 7$	80 rafters	$2 \times 5 \times 16$
14 top posts	$5 \times 5 \times 13$	80 rafters	$2 \times 5 \times 8$
90 streamers and plates	$2 \times 5 \times 12$	30 braces	$2 \times 5 \times 14$
14 girders	$6 \times 6 \times 12$	Siding, 3,300 feet	$1 \times 12 \times 12$
16 plates	$4 \times 6 \times 12$	270 strips	$\frac{3}{4} \times 4 \times 12$
8 ties	$2 \times 6 \times 10$	50 pieces cornice	$1 \times 7 \times 12$
		Sheathing	4,000 feet

Determine the total number of feet of lumber. (See page 51.)

16. A farmer had a 12′ × 36′ silo (inside measurements). If $1\frac{1}{2}$ inches of silage should be removed from the top to insure good silage, how many cows ought he to feed, when 40 pounds are fed per animal per day? Calculate average weight of silage at 40 pounds per cubic foot.

(a) How long will the silage last at this rate of feeding when there are 33 feet of silage to be fed?

17. At the West Virginia Experiment Station* a record of 600 hens (Single Comb White Leghorn pullets at start) was kept for one year, as follows:

Amounts and Cost of Feed Consumed

Cornmeal	3,441	lbs.	$42.88
Wheat Bran	5,434	lbs.	71.74
Wheat Middlings	2,932	lbs.	39.82
Oil Meal	950	lbs.	18.72
Wheat	10,509.6	lbs.	152.21
Corn	8,952	lbs.	103.81
Beef Scrap	2,443	lbs.	57.70
Green Cut Bone	178	lbs.	1.33
Ensilage	1,536	lbs.	3.75
Rye	1,120	lbs.	16.80
Ground Oats	337	lbs.	5.73
Oyster Shell	1,510	lbs.	8.30
Mica Crystal Grit	1,400	lbs.	7.70
Skim Milk	205	gals.	4.10

Number and Value of Eggs Produced

November	$85\frac{3}{4}$	doz.	@ 35c.
December	281	"	" 40c.
January	$387\frac{1}{12}$	"	" 35c.
February	$481\frac{11}{12}$	"	" 30c.
March, 1-10	$231\frac{7}{12}$	"	" 30c.
March, 10-15	$125\frac{3}{4}$	"	" 22c.
March, 15-31	$459\frac{3}{4}$	"	" 20c.
April	$737\frac{11}{12}$	"	" 20c.
May	$722\frac{7}{12}$	"	" 20c.

*West Virginia Experiment Station, Bulletin No. 115.

June, 1-14	$295\frac{1}{2}$	"	" 20c.
June, 14-30	$321\frac{1}{8}$	"	" 25c.
July	$552\frac{2}{3}$	"	" 25c.
August	$435\frac{5}{12}$	"	" 25c.
August	$72\frac{1}{2}$	"	" 28c.
September	264	"	" 30c.
September	$62\frac{1}{3}$	"	" 32c.
October	$46\frac{2}{3}$	"	" 35c.
October	$82\frac{1}{4}$	"	" 40c.

(a) Determine the total cost of feed.

(b) Determine the value of the eggs for each month and total for year.

(c) How many eggs were produced in all? Average per fowl? Average value of eggs per fowl?

(d) The other expenses were \$120 for labor, \$36 for fowls which died, \$100 for depreciation and \$66 for interest on investment. What were the total net profits? Average per hen?

(e) How much money was represented in the investment?

18. Which weighs the more and how much more; 10 pounds of cotton or 10 pounds of gold? (See page 245).

19. Make out a list of 15 groceries and amount of each that may be purchased at local prices for the money spent during a year for liquor or tobacco at the rate of 15 cents per day.

20. Land purchased at \$175 per acre produced a net profit in crop value of \$20 per acre. (Land rental of 5% was charged against the crop.) What per cent income was realized from this land investment?

(a) This investment is equal to how much money let out at 5%? At 6%?

21. Mr. B learned that rock phosphate containing about 32% "phosphoric acid," (P_2O_5), could be purchased

for about \$10 per ton (including freight). When he wanted to buy some and was offered a good grade of this fertilizer having a guarantee of 13.5% phosphorus (*P*), at \$9 per ton, he suspected dishonesty.

Write a letter to this man explaining that the price was reasonable. (See page 155.)

22. In a thousand parts by weight of a fertile silt loam soil, are how many parts of the element phosphorus? (See page 132.) If this portion were removed could any plant grow in that soil?

23. Four pounds of shelled corn is equal to what decimal part of a bushel of cured ear corn?

24. Tuberculosis, which claims more victims than any other disease in the United States, was the cause of 147,200 deaths in 1910*. Out of 100,000 population how many died of this disease during that year? (See page 79, problem 6.)

(a) In 1900 when the population of the United States was 76 millions, 204 out of 100,000 died of tuberculosis. Determine the number of deaths resulting from this cause in 1900.

(b) Determine the per cent of decrease in the number of deaths resulting from this White Plague between the years 1900 and 1910.

25. A soft water faucet leaked 48 drops a minute. How many gallons of water leaked away during 24 hours? (A drop of water weighs approximately .14 grams.) (See page 245.)

(a) The faucet leaked for 6 weeks before it was repaired. How many barrels of water were lost through leakage?

26. If cow manure were reduced to the same water content as sheep manure, how would the per cents of the fertility elements compare? (See page 149.)

*Digest of 1910, U. S. Census.

Figure 39.—Finderne Pride Johanna Rue (Holstein), once the champion dairy cow of the world. She completed her 365-day record, June, 1915, after producing 28,403.7 lbs. milk containing 1,176.47 lbs. butter-fat.
Courtesy of Wis. Live Stock Ass'n.

27. When Finderne Pride Johanna Rue, (Holstein), completed her 365-day record, June, 1915, she became the world's champion dairy cow,* producing in one year 28,403.7 pounds of milk, containing 1,176.47 pounds of butter-fat. What was the average test of her milk?

(a) How many more pounds of butter-fat were produced by this cow than by the world's champion before her? (See page 89, problem 14.)

(b) 1,176.47 pounds of butter-fat is equivalent to how many pounds of 85% butter? (Assuming no loss of fat.) Value of butter at 30 cents per pound? Value of skim milk at 20 cents per hundred? Total value of dairy products?

*Finderne Pride Johanna Rue lost her world's championship to Duchess Skylark Ormsby, (Holstein), Nov. 1915. The latter produced 1205.09 pounds of butter-fat in 365 days.

(c) How many cows averaging 30 pounds of milk testing 3.5% and milking for 270 days, are required to equal the yearly production of Finderne Pride Johanna Rue?

28. What per cent more digestible mineral matter has whole wheat flour than white wheat flour?

29. What per cent of the protein in timothy hay is digestible? In clover hay? In alfalfa hay?

30. A farmer agreed to let his son Henry have all the profits from the sale of 2 acres of corn, with the understanding that Henry pay his father $10 per acre as cost to raise the corn (excluding Henry's time) and also pay 15 cents per pound for the nitrogen, 10 cents for the phosphorus and 6 cents per pound for the potassium removed by the crop. The corn yielded 75 bushels of shelled corn and 2.02 tons of stover per acre. The corn was sold for 60 cents per bushel and the stover for $2.75 per ton. How much money did Henry realize from his transaction?

31. On one of two plots of acid silt loam were applied 3 tons of pulverized limestone per acre. (1914.) Red clover was seeded. The following year 50.5 pounds of green clover containing 76.6% water were cut from an average square rod on the unlimed plot, and 69 pounds containing 75.5% water were cut per square rod from the limed area. Determine the production of dry matter per acre on each plot. What was the per cent increase due to liming?

32. Eighty acres of prairie soil rented to a large grain farmer produced in 10 years the following crops:

Crops	*Acres*	*Average Yield per Acre*
Corn	160	40 bu.
Oats	120	40 "
Wheat	180	20 "
Barley	100	35 "
Clover	80	1.5 tons
Timothy	160	2 "

All crops were taken from the "80" and no fertility returned. At the beginning of the 10-year lease the land was valued at $175 per acre, and during the rental period land value increased 20%. Was this increase sufficient to offset the value of the fertility removed by the crops? Consider value of nitrogen at 15 cents, phosphorus at 10 cents and potassium at 6 cents per pound.

33. If on the "80" in problem 32, 30 acres of corn, 30 of oats and 20 of clover were raised in a year, yielding as above, and all crops fed on the "80," and manure hauled directly to the land, how much fertility (nitrogen, phosphorus and potassium) would be lost from the soil? (Assume no feeds purchased.) (See page 137.)

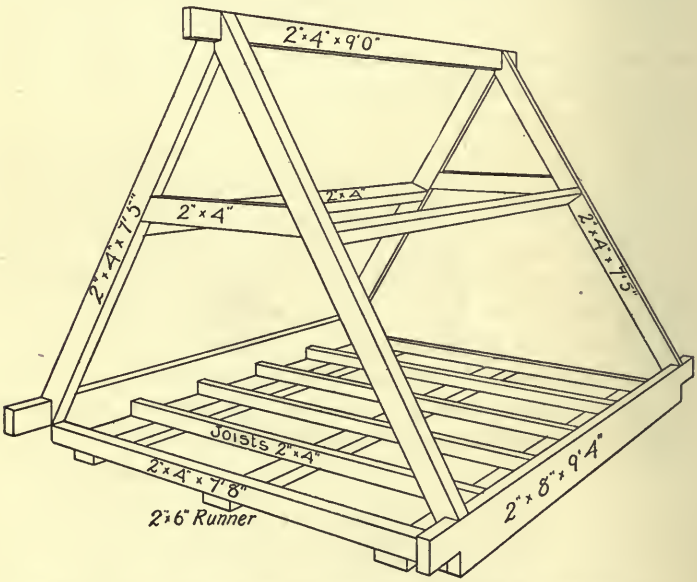

Figure 40.—Frame Work of an A-Shaped Portable Hog House as Shown in Fig. 41. Courtesy of Wis. Agr'l Exp. Sta.

(a) About how many 30-bushel wheat crops raised and sold (straw and grain sold) would cause an equal loss of phosphorus? Of nitrogen? Of potassium?

34. Obtain the local prices per M feet of the materials in the following bill of lumber necessary to construct an A-shaped portable hog house* as shown in Figures 40 and 41, and determine the total cost of the lumber.

9 pieces 1″ × 12″ × 16′ and 11 O. G. batten 16 ft. long for roof.
3 pieces 2″ × 6″ × 16′ and 11 O. G. batten 16 ft. long for roof.
5 pieces 1″ × 12″ × 14′ for ends.
1 piece 2″ × 4″ × 10′ for ridge.
2 pieces 2″ × 8″ × 10′ for plates.
7 pieces 2″ × 4″ × 16′ for rafters and braces in frame.
3 pieces 2″ × 6″ × 8′ for runners.
4 pieces 1″ × 12″ × 16′ rough for flooring.

Figure 41.—A-Shaped Portable Hog House. Courtesy of Wis. Agr'l Exp. Sta.

35. A 2-12-8 fertilizer costing $30.50 per ton was applied at the rate of 1,200 pounds per acre once in 3 years on some long-cropped, silt loam soil. The value of the increased crops covering 3 years was estimated at $52.15 per acre. When the same fertilizer was applied at the rate of 600 pounds once in 3 years on the same soil, the value of the increased crops was $31.57 per acre.

*Wisconsin Experiment Station, Bulletin No. 242.

(a) Determine the per cent of nitrogen, phosphorus and potassium in the fertilizer used. (See page 154 and 155.) How many pounds of each element in a ton?

(b) Determine the per cent profit* on cost of fertilizer invested above cost of fertilizer in each case.

(c) From the standpoint of available money, under these conditions, which would be better for a man of small means—to apply the fertilizer at the rate of 1,200 or 600 pounds per acre? For the man of ample means?

(d) Under similar conditions would it be more profitable for a man of small means to borrow for 2 years at 6% all money used to purchase fertilizers, and apply 1,200 pounds per acre than to use his own money for this purpose and apply 600 pounds?

(e) Does it necessarily follow under like conditions that the more fertilizers applied per acre the greater the amount of profits?

*It is a well established fact that on soils which respond to fertilizers a greater per cent profit is realized from a light application of a required fertilizer than from a heavy application.

APPENDIX

Average Composition of Some Common Feeds*
Amount in 100 Pounds

Feeds	Water	Ash	Crude protein	Carbohydrates		Fat
				Fiber	Nitrogen-free extract	
Alfalfa hay	8.6	8.6	14.9	28.3	37.3	2.3
Barley (grain)	9.3	2.7	11.5	4.6	69.8	2.1
Brewers' grains (dried)	7.5	3.5	26.5	14.6	41.0	6.9
Clover hay, alsike	12.3	8.3	12.8	25.7	38.4	2.5
Clover hay, crimson	10.6	8.8	14.1	27.3	36.9	2.3
Clover hay, Japan	11.8	5.8	12.1	25.9	41.6	2.8
Clover hay, red	12.9	7.1	12.8	25.5	38.7	3.1
Clover hay, sweet, (white)	8.6	7.2	14.5	27.4	40.1	2.2
Clover and timothy hay (mixed)	12.2	6.1	8.6	29.9	40.8	2.4
Corn, dent	10.5	1.5	10.1	2.0	70.9	5.0
Corn, flint	12.2	1.5	10.4	1.5	69.4	5.0
Corn meal	11.3	1.3	9.3	2.3	72.0	3.8
Corn silage (well matured)	73.7	1.7	2.1	6.3	15.4	0.8
Corn stover (ears removed, very dry)	9.4	5.8	5.9	30.7	46.6	1.6
Cottonseed meal (good)	7.9	6.4	37.6	11.5	28.4	8.2
Cowpeas	11.6	3.4	23.6	4.1	55.8	1.5
Cowpeas hay	9.7	11.9	19.3	22.5	34.0	2.6
Germ oil meal (high grade)	8.9	2.7	22.6	9.0	46.0	10.8
Gluten feed (high grade)	8.7	2.1	25.4	7.1	52.9	3.8
Gluten meal	9.1	1.1	35.5	2.1	47.5	4.7
Johnson grass hay	10.1	7.5	6.6	30.2	43.5	2.1
Mangels	90.6	1.0	1.4	0.8	6.1	0.1
Milk, cow's (whole)	86.4	0.7	3.5	.....	5.0	4.4
Milk, skim	90.1	0.7	3.8	.....	5.2	0.2
Millet hay (common)	14.3	6.3	8.3	24.0	44.3	2.8
Mixed grasses, hay	12.8	5.6	7.6	28.8	42.7	2.5
Oats	9.2	3.5	12.4	10.9	59.6	4.4
Oats straw	11.5	5.4	3.6	36.3	40.8	2.4
Oil meal (old process)	9.1	5.4	33.9	8.4	35.7	7.5
Potatoes	78.8	1.1	2.2	0.4	17.4	0.1
Rice meal	9.5	9.1	11.8	9.3	48.7	11.6
Rye	9.4	2.0	11.8	1.8	73.2	1.8
Soybeans	9.9	5.3	36.5	4.3	26.5	17.5

*Compiled from Feeds and Feeding, Henry and Morrison, 15th Edition, 1915.

Average Composition of Some Common Feeds (Cont.)
Amount in 100 Pounds

Feeds	Water	Ash	Crude protein	Carbohydrates		Fat
				Fiber	Nitrogen-free extract	
Soy beans hay	8.6	8.6	16.0	24.9	39.1	2.8
Sugar beets (roots)	86.3	1.1	1.6	1.0	12.6	0.1
Tankage (high grade)	7.5	12.0	60.5	4.2	2.7	13.0
Timothy hay	11.6	4.9	6.2	29.9	45.0	2.5
Wheat	10.2	1.9	12.4	2.2	71.2	2.1
Wheat bran	10.1	6.3	16.0	9.5	53.7	4.4
Wheat middlings (shorts)	10.4	4.4	17.3	6.0	57.0	4.9
Wheat screenings	10.2	3.9	13.3	7.4	61.1	4.1
Whey	92.5	1.6	1.0	.....	4.6	0.3

Haecker's Feeding Standard for the Dairy Cow

	Daily allowance of digestible nutrients		
	Crude Protein	Carbohydrates	Fat
	Lbs.	Lbs.	Lbs.
For support of the 1000-lb. cow	0.7	7.0	0.1
To the allowance for support add:			
For each lb. of 3.0 per cent milk	0.047	0.20	0.017
For each lb. of 3.5 per cent milk	0.049	0.22	0.019
For each lb. of 4.0 per cent milk	0.054	0.24	0.021
For each lb. of 4.5 per cent milk	0.057	0.26	0.023
For each lb. of 5.0 per cent milk	0.060	0.28	0.024
For each lb. of 5.5 per cent milk	0.064	0.30	0.026
For each lb. of 6.0 per cent milk	0.067	0.32	0.028

Digestible Nutrients in Some Common Foods*

Kind of Food	Per cent		Per cent Digestible Nutrients and Mineral Matter (ash)			
	Refuse	Water	Protein	Carbohydrates	Fat	Mineral Matter
Animal Foods						
Beef, fresh						
Flank	10.2†	54.0	16.5	0.0	18.0	0.5
Sirloin steak	12.8	54.0	16.0	0.0	15.3	0.7
Neck	27.6	45.9	14.1	0.0	11.3	0.5
Ribs	20.8	43.8	13.5	0.0	20.0	0.5
Round	7.2	60.7	18.4	0.0	12.2	0.8
Shoulders and clod	16.4	56.8	16.0	0.0	9.3	0.7
Beef, dried	4.7	53.7	25.6	0.0	6.6	5.5
Dairy Products						
Butter	0.0	11.0	1.0	0.0	80.8	2.3
Buttermilk	0.0	91.0	3.0	4.7	0.5	0.5
Cream	0.0	74.0	2.4	4.5	17.6	0.4
Cheese, cheddar	0.0	27.4	26.9	4.0	35.0	3.0
Cheese, full cream	0.0	34.2	25.0	2.4	32.0	2.9
Cheese, limburger	0.0	35.7	33.2	2.9	23.0	2.2
Cheese, Swiss	0.0	36.1	27.0	2.5	28.0	2.3
Milk, whole	0.0	87.0	3.2	5.0	3.8	0.5
Milk, skim	0.0	90.5	3.3	5.1	0.3	0.5
Eggs, hens'	11.2	65.5	12.7	0.0	8.8	0.7
Fish						
Cod, salt	24.9	40.2	15.5	0.0	0.4	13.9
Mackerel (fresh)	44.7	40.7	9.9	0.0	4.0	0.5
Salmon, canned	0.0	63.5	21.1	0.0	11.5	2.0
Lobster	61.7	30.7	5.7	0.2	6.7	0.6
Oysters	0.0	88.3	5.8	3.3	1.2	0.8
Mutton						
Flank	9.9	39.0	13.4	0.0	35.0	0.5
Leg, hind	18.4	51.2	14.6	0.0	14.0	0.6
Fore quarter	21.2	41.6	12.0	0.0	23.3	0.5
Hind quarter (without tallow)	17.2	45.4	13.4	0.0	22.0	0.5
Pork						
Bacon, smoked	7.7	17.4	8.8	0.0	59.1	3.1
Ham, fresh	10.7	48.0	13.1	0.0	24.6	0.6
Ham, smoked	13.6	34.8	13.8	0.0	31.7	3.2
Loin chops	19.7	41.8	13.0	0.0	23.0	0.6
Shoulder	12.4	44.9	11.6	0.0	28.3	0.5
Shoulder, smoked	18.2	36.8	12.6	0.0	25.3	0.4
Salt pork	0.0	7.9	1.8	0.0	81.9	2.9
Tenderloin	0.0	66.5	18.3	0.0	12.4	0.8
Sausage (pork)	0.0	39.8	12.6	1.1	42.0	1.7

*Compiled mainly from U. S. Farmers' Bulletin No. 142
†Per cents refer to total amount purchased.

Digestible Nutrients in Some Common Foods (Continued)

Kind of Food	Per cent		Per cent Digestible Nutrients and Mineral Matter (ash)			
	Refuse	Water	Protein	Carbohydrates	Fat	Mineral Matter
Poultry						
Fowls	25.9	47.1	13.3	0.0	11.7	0.5
Goose	17.6	38.5	13.0	0.0	28.3	0.5
Turkey	22.7	42.4	15.6	0.0	17.5	0.6
Veal						
Leg	14.2	60.1	15.0	0.0	7.5	0.7
Fore quarter	24.5	54.2	14.6	0.0	5.7	0.5
Hind quarter	20.7	56.2	15.7	0.0	6.3	0.6
Vegetable Foods						
Bread, pastry, etc.						
Cream crackers	0.0	6.8	8.2	68.3	10.9	1.3
Graham bread	0.0	35.7	7.5	50.5	1.6	1.1
Rye bread	0.0	35.7	7.6	51.6	0.5	1.1
White bread (wheat)	0.0	35.3	7.8	52.0	1.2	0.8
Whole-wheat bread	0.0	38.4	8.2	48.3	0.8	1.0
Breakfast foods						
Corn meal	0.0	12.5	7.8	73.9	1.7	0.8
Cream of wheat	0.0	8.8	11.1	74.7	5.4	0.4
Grape nuts	0.0	6.2	10.2	77.7	5.5	1.5
Oat meal	0.0	7.8	14.2	64.9	6.6	1.4
Quaker oats	0.0	7.8	12.5	68.4	5.6	1.1
Flour, rice, etc.						
Buckwheat flour	0.0	13.6	5.4	76.1	1.1	0.7
Graham flour	0.0	11.3	11.3	70.0	2.0	1.4
Macaroni	0.0	10.3	11.4	72.6	0.8	1.0
Popcorn, popped	0.0	4.3	9.1	77.1	4.5	1.0
Rice	0.0	1.2	6.8	77.4	0.3	0.3
Rye flour	0.0	12.9	5.8	77.1	0.8	0.5
Tapioca	0.0	11.4	0.3	86.2	0.1	0.1
Wheat flour	0.0	12.0	9.7	73.6	0.9	0.4
Whole-wheat flour	0.0	11.4	11.7	70.5	1.8	0.8
Fruits						
Apples	25.0	63.3	0.3	9.7	0.3	0.2
Apples, dried	0.0	28.1	1.4	59.5	2.0	1.5
Apricots, dried	0.0	29.4	3.9	61.9	0.9	1.8
Bananas	35.0	48.9	0.7	12.9	0.4	0.5
Figs, dried	0.0	18.8	3.7	66.8	0.3	1.8
Grapes	25.0	58.0	0.9	13.0	1.1	0.3
Oranges	27.0	63.4	0.5	7.7	0.1	0.3
Raisins	10.0	13.1	2.0	61.7	2.7	2.3

Digestible Nutrients in Some Common Foods (Continued)

Kind of Food	Per cent		Per cent Digestible Nutrients and Mineral Matter (ash)			
	Refuse	Water	Protein	Carbohydrates	Fat	Mineral Matter
Nuts						
Almonds	45.0	2.7	9.5	9.0	27.2	0.8
Brazil nuts	49.6	2.6	7.1	3.3	30.3	1.5
Filberts	52.1	1.8	6.2	5.9	28.2	0.8
Pecans, polished	53.2	1.4	4.3	5.9	30.0	0.5
Peanuts	24.5	6.9	16.2	17.6	26.2	1.1
Walnuts, English	58.1	1.0	5.7	6.5	24.0	0.5
Vegetables						
Beans, white dried	0.0	12.6	17.2	57.8	1.6	2.6
Beans, string	7.0	83.0	1.7	6.6	0.3	0.5
Beans, baked	0.0	68.9	5.7	18.6	2.3	1.6
Beets	20.0	70.0	1.1	7.3	0.9	0.7
Cabbage	15.0	77.7	1.2	4.6	0.2	0.7
Celery	20.0	75.6	0.8	2.5	0.1	0.6
Corn, green (edible part)	0.0	75.4	2.6	18.7	1.0	0.5
Lettuce	1.5	80.5	0.8	2.4	0.2	0.6
Onions	10.0	78.9	1.2	8.5	0.3	0.4
Peas, green, shelled	0.0	74.6	6.0	16.0	0.5	0.8
Potatoes	20.0	62.6	1.5	14.0	0.1	0.6
Spinach	0.0	92.3	1.8	3.0	0.3	1.6
Tomatoes	0.0	94.3	0.7	3.7	0.4	0.4
Miscellaneous						
Cocoa (drink made with milk)	0.0	84.5	3.3	5.8	4.2	.....
Coffee (drink)	0.0	98.2	0.2	1.3	0.0	0.1
Tea (drink)	0.0	99.5	0.2	0.6	0.0	.....
Soups						
Beef	0.0	92.9	4.3	1.1	0.4	0.9
Tomato	0.0	90.0	1.7	5.5	1.0	1.1
Sugar (gran.)	0.0	0.0	0.0	98.0	0.0	0.0
Potato chips	0.0	4.6	4.7	42.6	34.7	3.1

Pounds of Plant-Food Elements Removed by Crops.*
(Approximate amounts per acre annually)

Crops	Yield per acre	Nitrogen (N)	Phosphorus (P)	Potassium (K)	Calcium (Ca)
Alfalfa hay	4 tons	(190.4)†	18.9	148.0	145.0
Barley, grain	40 bu.	35.3	7.1	11.8	0.8
straw	1 ton	11.2	1.57	19.9	4.6
Total crop	.....	46.5	8.67	31.7	5.4
Buckwheat, grain	30 bu.	21.8	5.5	7.3	0.3
straw	¾ ton	12.45	0.85	14.1	10.3
Total crop	.....	34.25	6.35	21.4	10.6
Cabbage	20 tons	120.0	20.0	144.0	36.0
Clover hay (red)	2 tons	(82.0)	6.8	54.0	61.6
Clover hay (Japan)	2 tons	(77.6)	18.0	68.8	.....
Clover and timothy (mixed)	2 tons	(55.2)	8.0	63.2	.....
Clover seed	3 bu.	(5.25)	1.5	2.25	3.2
Corn, grain	65 bu.	59.0	10.9	12.1	0.7
stover	1¾ tons	33.0	6.86	37.45	12.2
cob	900 lbs.	2.9	0.3	4.9	0.1
Total crop	.....	94.9	18.06	54.45	13.0
Cotton, lint	500 lbs	1.5	[0.2	2.0	.....
seed	1000 lbs	31.5	5.5	9.5	.....
stalk	2000 lbs	51.0	9.0	29.5	.....
Total crop	.....	84.0	14.7	41.0	.....
Cowpeas, hay	2 tons	(123.6)	16.4	137.2	36.0
Flax, grain	15 bu.	30.4	5.5	6.63	2.0
straw	0.9 ton	20.7	1.5	15.66	9.3
Total crop	.....	51.1	7.0	22.3	11.3
Millet hay (common	3 tons	79.8	9.4	106.8	16.2
Oats, grain	50 bu.	31.7	5.65	7.44	1.1
straw	1¼ tons	14.5	2.25	31.13	7.5
Total crop	.....	46.2	7.9	38.57	8.6
Peas, grain	25 bu.	54.9	5.5	12.6	2.3
straw	1½ tons	30.3	2.5	26.3	42.3
Total crop	.....	(85.2)	8.0	38.9	44.6
Potatoes (tubers)	200 bu.	42.0	6.3	52.8	2.4

*Compiled from various sources.

†Figures in parentheses in Nitrogen column indicate total nitrogen content of the leguminous crops. See pages 127, 136.

Pounds of Plant-Food Elements Removed by Crops. (Con't.)

(Approximate amounts per acre annually)

Crops	Yield per acre	Nitrogen (N)	Phosphorus (P)	Potassium (K)	Calcium (Ca)
Rye, grain	25 bu.	26.5	4.48	6.6	0.56
straw	1¼ tons	12.0	3.05	16.4	5.5
Total crop	.....	38.5	7.53	23.0	6.06
Soybeans, grain	20 bu.	70.0	7.1	24.6	2.2
straw	1½ tons	52.7	5.4	32.7	31.2
Total crop	.....	(122.7)	12.5	57.3	33.4
Sugar beets, (roots only)	15 tons	78.0	10.5	79.5	9.0
Timothy hay	1½ tons	29.7	4.05	33.9	7.5
Tobacco, (leaves)	1500 lbs	65.0	3.3	70.5	48.0
Wheat, grain	30 bu.	35.6	6.75	7.92	0.7
straw	1.6 tons	16.0	1.8	19.64	4.2
Total crop	.....	51.6	8.55	27.56	4.9

Specific Gravity of a Few Substances

Aluminium	2.58	Iron	7.93	Platinum	21.50
Calcium	1.54	Lead	11.38	Potassium	.87
Copper	8.89	Mercury	13.59	Silicon	2.35
Gold	19.30	Nickel	8.90	Silver	10.50
Granite	2.60	Phosphorus	1.80	Sodium	.97

Specific gravity is the relative density or weight of any volume of a substance compared with an equal volume of some other substance taken as the standard or unit. Solids and liquids are compared with water.

A body submerged in a liquid displaces an equal volume of the liquid. A body floating in a liquid displaces an equal weight of the liquid.

Weights Per Bushel of Grain, Seeds, etc., in Different States.

States	Barley	Beans (white)	Blue grass seed	Buckwheat	Clover seed	Corn (shelled)	Corn on cob	Flax seed	Oats	Onions	Potatoes	Rye	Sweet Potatoes	Timothy seed	Turnips	Wheat
Alabama	47	60	..	48	60	56	70	..	32	57	60	56	55	45	55	60
Arkansas	48	60	14	52	60	56	70	56	32	57	60	56	50	60	57	60
Arizona	45	55	..	..	..	..	..	..	32	..	..	..	..	..	..	..
California	50	..	..	40	..	52	..	..	32	..	..	54	..	..	..	60
Colorado	48	60	14	52	60	56	70	..	32	57	60	56	..	45	..	60
Connecticut	48	60	..	48	60	56	..	55	32	50	60	56	54	..	50	60
Delaware	..	..	..	..	..	56	..	..	..	..	..	..	..	..	..	60
District of Columbia	47	62	..	48	60	56	..	..	32	57	60	56	..	45	55	60
Florida	48	60	..	48	60	56	..	..	32	57	..	56	60	45	55	60
Georgia	47	60	14	52	60	56	70	56	32	57	60	56	55	45	55	60
Idaho	48	..	..	42	60	56	..	56	36	..	60	56	..	..	..	60
Illinois	48	60	14	52	60	56	70	56	32	57	60	56	50	45	55	60
Indiana	48	60	14	50	60	56	68	..	32	48	60	56	55	45	..	60
Iowa	48	60	14	52	60	56	70	56	32	57	60	56	46	45	..	60
Kansas	48	60	14	50	60	56	70	56	32	57	60	56	50	45	55	60
Kentucky	47	60	14	56	60	56	68	56	32	57	60	56	55	45	60	60
Louisiana	48	..	..	..	..	56	..	..	32	..	..	..	..	..	..	..
Maine	48	60	..	48	..	56	..	..	32	52	60	..	..	45	60	60
Maryland	..	62	..	..	..	..	..	..	26	..	56	56	..	..	..	..
Massachusetts	48	60	..	48	60	56	..	55	32	52	60	56	54	45	..	60
Michigan	48	60	14	48	60	56	70	56	32	54	60	56	56	45	58	60
Minnesota	48	60	14	50	60	56	70	..	32	57	60	56	55	45	52	60
Mississippi	48	60	14	..	60	56	72	56	32	57	60	56	60	45	55	60
Missouri	48	60	14	52	60	56	..	56	32	57	60	56	56	45	42	60
Montana	48	60	14	52	60	56	70	56	32	57	60	56	..	45	50	60
Nebraska	48	60	14	52	60	56	70	56	32	52	60	56	50	45	55	60
Nevada	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
New Hampshire	..	62	..	..	..	56	..	..	32	..	60	56	..	..	..	60
New Jersey	48	60	..	50	64	56	..	55	30	57	60	56	54	45	..	60
New Mexico	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
New York	48	62	..	48	60	58	..	55	32	57	60	56	54	44	..	60
North Carolina	48	..	..	50	64	54	..	55	32	..	..	56	..	..	..	60
North Dakota	48	60	..	42	60	56	70	56	32	52	..	56	46	45	60	60
Ohio	48	60	..	50	60	56	68	56	32	55	..	56	50	45	60	60
Oklahoma	48	60	..	42	60	56	70	56	32	52	..	56	46	42	60	60
Oregon	46	..	..	42	60	..	..	..	36	..	60	56	..	..	..	60
Pennsylvania	47	..	..	48	60	..	..	..	32	50	56	56	..	..	..	60
Rhode Island	48	60	..	48	60	56	70	56	32	50	..	56	54	45	50	60

Weights Per Bushel of Grain, Seeds, etc., in Different States —Continued.

States	Barley	Beans (white)	Blue grass seed	Buckwheat	Clover seed	Corn (shelled)	Corn on cob	Flax seed	Oats	Onions	Potatoes	Rye	Sweet Potatoes	Timothy seed	Turnips	Wheat
South Carolina	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
South Dakota	48	60	..	42	60	56	70	56	32	52	..	56	46	42	60	60
Tennessee	48	60	14	50	60	56	70	56	32	56	..	56	50	45	50	60
Texas	48	60	..	42	60	56	70	56	32	57	..	56	55	45	55	60
Utah	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Vermont	48	62	..	48	60	..	..	..	32	52	60	56	..	45	60	60
Virginia	48	60	14	52	60	56	70	56	30	57	..	56	56	45	55	60
Washington	48	..	..	42	60	..	..	56	32	..	60	56	..	..	..	60
West Virginia	48	60	..	52	60	..	..	56	32	..	60	56	..	45	..	60
Wisconsin	48	60	..	50	60	56	70	56	32	57	60	56	54	45	42	60
Wyoming	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
United States	48	..	..	42	..	..	..	56	32	..	60	56	..	..	..	60

The Wolff Feeding Standards for Farm Animals

Animal	Per day per 1000 lbs. live weight			
	Dry matter	Digestible nutrients		
		Crude protein	Carbo-hydrates	Fat
Fattening cattle—				
First period	30	2.5	15.0	0.5
Second period	30	3.0	14.5	0.7
Third period	26	2.7	15.0	0.7
Milch cows,—when yielding				
16.6 lbs. of milk	27	2.0	11.0	0.4
22.0 lbs. of milk	29	2.5	13.0	0.5
27.5 lbs. of milk	32	3.3	13.0	0.8
Horses—				
Light work	20	1.5	9.5	0.4
Medium work	24	2.0	11.0	0.6
Heavy work	26	2.5	13.3	0.8
Brood sows	22	2.5	15.5	0.4
Fattening swine—				
First period	36	4.5	25.0	0.7
Second period	32	4.0	24.0	0.5
Third period	25	2.7	18.0	0.4
Growing fattening swine—				
Weighing 50 lbs	44	7.6	28.0	1.0
Weighing 100 lbs	35	5.0	23.1	0.8
Weighing 150 lbs	33	4.3	22.3	0.6
Growing sheep—mutton breeds				
Weighing 60 lbs	26	4.4	15.5	0.9
Weighing 80 lbs	26	3.5	15.0	0.7
Weighing 100 lbs	24	3.0	14.3	0.5
Fattening sheep—				
First period	30	3.0	15.0	0.5
Second period	28	3.5	14.5	0.6

TABLES OF WEIGHTS

Avoirdupois or Commercial Weight.

16 drams = 1 ounce (oz.)
16 ounces = 1 pound (lb.)
100 pounds = 1 hundredweight (cwt.)
2000 pounds = 1 ton (T.)

The following denominations are also used in Avoirdupois Weight—

100 lbs. nails = 1 keg
196 lbs. flour = 1 barrel
200 lbs. pork or beef = 1 barrel
230 lbs. salt (at N. Y. works) = 1 barrel

Troy or Jeweler's Weight.

24 grains = 1 pennyweight (pwt.)
20 pennyweight = 1 ounce
12 ounces = 1 pound

Metric Equivalent of Avoirdupois Weight.

1 dram = 1.77 grams (g.)
1 ounce = 28.35 grams
1 pound = .4536 kilogram (K.), or kilo.
1 kilogram = 2.2 pounds
1 ton = .9 metric ton

UNITED STATES DRY AND LIQUID MEASURES

Dry Measure.

2 pints (pt.) = 1 quart (qt.)
8 quarts = 1 peck (pk.)
4 pecks = 1 bushel (bu.)
1 bushel = 2,150.42 cubic inches, or 1.2 cu. ft.
1 heaped bushel = 2,747.7 cubic inches, or 1.6 cu. ft.

Liquid Measure.

4 gills (gi.) = 1 pint (pt.)
2 pints = 1 quart (qt.)
4 quarts = 1 gallon (gal.)
1 gallon = 231 cu. in.
31½ gallons = 1 barrel (bbl.)
2 barrels, or 63 gallons = 1 hogshead.

In approximate values 7½ gallons = 1 cu. ft., 4⅘ cu. ft. = 1 barrel.

Metric equivalent of dry and liquid measures.

1 liquid quart = .95 liter
1 quart in dry measure = 1.1 liters
1 liter = 1.05 liquid quarts, or .9 dry quart.

LINEAR MEASURE

12 inches (in.) = 1 foot (ft.) 5½ yards, or 16½ feet = 1 rod (rd.)
3 feet = 1 yard (yd.) 320 rods, or 5280 feet = 1 mile (mi.)

SQUARE MEASURE

144 square inches (sq. in.) = 1 square foot (sq. ft.)
9 square feet = 1 square yard (sq. yd.)
160 square rods = 1 acre (A.)
640 acres = 1 square mile (sq. mi.), or section (sec.)

SOLID OR CUBIC MEASURE

1,728 cubic inches (cu. in.) = 1 cubic foot (cu. ft.)
27 cubic feet = 1 cubic yard (cu. yd.)

METRIC MEASURE OF LENGTH

10 millimeters (mm.) = 1 centimeter (cm.)
10 centimeters = 1 decimeter (dm.)
10 decimeters = 1 meter (m.)

Metric equivalent of linear, square, and cubic measures.

1 inch (in.) = 2.54 centimeters (cm.)
1 inch = 25.4 millimeters (mm.)
1 yard = .914 meter (m.)
1 meter = 3.28 feet
1 mile = 1.609 kilometers (km.)
1 hectare = 2.47 acres
1 cubic centimeter (c.c.) = 0.061 cu. in.

MISCELLANEOUS TABLE

12 units = 1 dozen (doz.)
12 dozen = 1 gross
20 units = 1 score
24 sheets = 1 quire
20 quires = 1 ream
4 inches = 1 hand (used in measuring height of horses)
3 feet = 1 pace
4′ x 4′ x 8′ = 1 cord wood.

TABLE OF HOUSEHOLD MEASURES

3 teaspoonfuls (tsp.) = to 1 tablespoonful (tbsp.)
2 cupfuls (c.) = to 1 pint (pt.)
4 cupfuls (about) flour = 1 lb.
2 c. sugar (gran.) = 1 lb.
2 c. butter packed solid = 1 lb.
2 c. chopped meat = 1 lb.
2 tbsp. butter (level full) = 1 oz.
1 tbsp. sugar (level full) = 1 oz.
1 tbsp. liquid = ½ oz.
8 or 10 eggs, depending on size, = 1 lb.
The juice of 1 lemon = 3 tbsp.

Average Dry Matter, Digestible Nutrients and Fertilizing Constituents in Some Common Feeds.*
Amount in 100 pounds.

Feeds	Dry matter	Digestible Nutrients			Fertilizing Constituents		
		Crude protein	Carbohydrates	Fat	Nitrogen (N)	Phosphorus (P)	Potassium (K)
Alfalfa hay	91.4	10.6	39.0	0.9	2.38	0.236	1.85
Barley (grain)	90.7	9.0	66.8	1.6	1.84	0.37	0.614
Brewers' grains (dried)	92.5	21.5	30.5	6.1	4.24	0.431	0.075
Clover hay, alsike	87.7	7.9	36.9	1.1	2.05	0.305	1.44
Clover hay, crimson	89.4	9.7	36.8	1.0	2.26	0.27	1.86
Clover hay, Japan	88.2	8.6	41.1	1.1	1.94	0.45	1.72
Clover hay, red	87.1	7.6	39.3	1.8	2.05	0.17	1.35
Clover hay, sweet, (white)	91.4	10.9	38.2	0.7	2.32	0.29	1.05
Clover and timothy hay (mixed)	87.8	4.0	39.7	1.1	1.38	0.2	1.58
Corn, dent	89.5	7.5	67.8	4.6	1.62	0.3	0.332
Corn, flint	87.8	7.7	66.1	4.6	1.66	0.296	0.324
Corn meal	88.7	6.9	69.0	3.5	1.49	0.283	0.31
Corn silage (well matured)	26.3	1.1	15.0	0.7	0.34	0.069	0.36
Corn stover (ears removed, very dry)	90.6	2.2	47.8	1.0	0.94	0.196	1.07
Cottonseed meal (good)	92.1	31.6	25.6	7.8	6.02	1.16	1.49
Cowpeas	88.4	19.4	54.5	1.1	3.78	0.44	1.24
Cowpeas hay	90.3	13.1	33.7	1.0	3.09	0.41	3.43
Germ oil meal (high grade)	91.1	16.5	42.6	10.4	3.62	0.575	0.21
Gluten feed (high grade)	91.3	21.6	51.9	3.2	4.06	0.27	0.19
Gluten meal	90.9	30.2	43.9	4.4	5.68	0.24	0.1
Johnson grass hay	89.9	2.9	45.0	1.0	1.06	0.183	0.94
Mangels	9.4	0.8	6.4	0.0	0.22	0.017	0.18

(*Compiled from Feeds and Feeding, Henry and Morrison, 15th Edition, 1915.)

Average Dry Matter, Digestible Nutrients and Fertilizing Constituents in Some Common Feeds. (Cont.)

Amount in 100 pounds.

Feeds	Dry matter	Digestible Nutrients			Fertilizing Constituents		
		Crude protein	Carbohydrates	Fat	Nitrogen (N)	Phosphorus (P)	Potassium (K)
Milk, cow's (whole)	13.6	3.3	4.9	4.3	0.56	0.083	0.14
Milk, skim	9.9	3.6	5.1	0.2	0.61	0.096	0.14
Millet hay (common)	87.5	5.0	46.0	1.8	1.33	0.157	1.78
Mixed grasses, hay	87.2	4.3	44.3	1.2	1.22	0.157	1.36
Oats	90.8	9.7	52.1	3.8	1.98	0.353	0.465
Oats straw	88.5	1.0	42.6	0.9	0.58	0.09	1.245
Oil meal (old process)	90.9	30.2	32.6	6.7	5.42	0.742	1.054
Potatoes	21.2	1.1	15.8	0.0	0.35	0.052	0.044
Rice meal	90.5	7.3	48.1	10.6	1.89	....	.....
Rye	90.6	9.9	68.4	1.2	1.89	0.32	0.473
Soybeans	90.1	30.7	22.8	14.4	5.84	0.594	2.05
Soybeans hay	91.4	11.7	39.2	1.2	2.56	0.296	1.93
Sugar beets (roots)	16.4	1.2	12.6	0.0+	0.26	0.035	0.265
Tankage (high grade)	92.5	56.3	....	12.7	9.7	2.14	0.72
Timothy hay	88.4	3.0	42.8	1.2	0.99	0.135	1.13
Wheat	89.8	9.2	67.5	1.5	1.98	0.375	0.44
Wheat bran	89.9	12.5	41.6	3.0	2.56	1.286	1.344
Wheat middlings (shorts)	89.6	13.3	46.3	4.3	2.77	0.92	0.98
Wheat screenings	89.9	9.6	47.3	3.6	2.13	0.322	0.63
Whey	7.5	1.0	4.5	0.7	0.16	0.052	0.215

SQUARE ROOT

The extraction 'of the square root is the analysis of the power into two equal factors. Hence it is important to see how the power was built up. In order not to lose the identity of the elements entering into the power, the multiplication is indicated, A. Compare the indicated expression with the algebraic formula, $(a + b)^2$. By studying operation A, it can be seen that the square of the tens figure, or any part of it, cannot lie in the first or second orders, and it must lie in the third order or in the third and fourth orders. If hundreds, as 200 or 900, were squared in the same way, it can be seen that the significant figures are in the fifth or fifth and sixth orders; hence we point off in periods of two orders.

$$
\begin{array}{rl}
 & 23 \\
\text{A} & 23 \\
\hline
 & 3\times3 \\
 & 2(20\times3) \\
 & 20\times20 \\
\hline
 & 20^2+2(20\times3)+3^2
\end{array}
$$

$$
\begin{array}{rl}
\text{B} & 400 \\
 & 120 \\
 & 9 \\
\hline
 & 529
\end{array}
$$

As 20 occupies the larger part of 500, (B), we take the largest square 400 from the product 529. The remainder, 129, in the main consists of twice the root 2 tens, or 40 times the units figure; hence to find the units figure, divide 129 by 40, or, for short, divide 12 by 4, making allowance for what else is in this number. As 129 contains 40×3 and also 3×3, it is the product of $(40 + 3) \times 3$ or 43×3; hence annex 3 to 4 the trial divisor, multiply and subtract, if there is a remainder. It can be shown by analyzing the squaring of a number of three orders, as 235, that the extraction of the root is but a repetition of the preceding process from this point on. If pupils have studied algebra, the analysis of $(a+b + c)$ is easier to understand, for it is a general statement of the above. It is interesting to note how the algebraic statement is symbolic of the arithmetical statement.

Square roots of numbers 1 to 20 inclusive correct to three decimal places.

$\sqrt{1}=1$	$\sqrt{8}=2.828$	$\sqrt{15}=3.873$
$\sqrt{2}=1.414$	$\sqrt{9}=3$	$\sqrt{16}=4$
$\sqrt{3}=1.732$	$\sqrt{10}=3.162$	$\sqrt{17}=4.123$
$\sqrt{4}=2$	$\sqrt{11}=3.316$	$\sqrt{18}=4.242$
$\sqrt{5}=2.236$	$\sqrt{12}=3.464$	$\sqrt{19}=4.359$
$\sqrt{6}=2.449$	$\sqrt{13}=3.605$	$\sqrt{20}=4.472$
$\sqrt{7}=2.645$	$\sqrt{14}=3.442$	

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ANSWERS

PART I

Page **31**—**1.** 1,890. **2.** 475. **3.** 1,500 lbs. **4.** $\frac{3}{7}$ and $\frac{4}{7}$. $541\frac{5}{7}$ and $722\frac{2}{7}$. **5.** 474 bu.

Page **32**—**4.** $17.78.

Page **33**—**5.** 320 acres. **6.** 40, 60, 160. **7.** $380.16. **8.** 1,584. **9.** 75,093.34.

Page **34**—**1.** E 40, D 160, A 80. **2.** $2,800. **3.** $1,800. **4.** $103.20. 43c.

Page **35**—**5.** 160 acres. 640 rds. 2 miles. **6.** 800 rds. 160 acres. 160 rds.

Page **36**—**1.** 480. **2.** 384 bu. **3.** 169 gal. 5.3 bbls.

Page **37**—**4.** 289 cu. ft. $32\frac{1}{3}$ bags. 3.57 cu. yds. sand. 5.94 cu. yds. gravel. **5.** 5.84 bags. .65 cu. yds. sand. 1.08 cu. yds. gravel. **6.** 285 bbls. **7.** 582 gal. **8.** 20 cords. **9.** 189 cords. **10.** 20 ft. $2\frac{1}{2}$ cords. **11.** 18. **12.** $\frac{1}{1\frac{1}{2}}$. **13.** 13.6″. **14.** 52,272 cu. ft.

Page **38**—**15.** 9.9 ft. **16.** 3 + acres. **17.** 11 and 10 tons. 8 and 10 tons. **19.** 10.8 ft. **20.** 1 ft. 5 in. **21.** 1.26 tons.

Page **40**—**9.** $11.28. **10.** 15.58. **11.** 430.05 sq. rds.

Page **41**—**7.** 2.69 acres. **8.** 183.4+. 600 bu. **9.** 143 bbls. **10.** 1,180.09.

Page **42**—**11.** 2.3 ft. 3.8 ft. **1.** 15. **2.** 11.7. **3.** 1.3.

Page **50**—**5.** 1,296 bu. **6.** $680.40.

Page **51**—**8.** 20. **9.** 1,920. **10.** 90 and 121. **11.** 14.9. **12.** 113.4 tons. **13.** $2,250.

Page **53**—**1.** $5.76. **2.** $6. **3.** $16. **4.** $19.20. **5.** $3.60. **6.** $20.70. **7.** $4.10. **8.** $20.74. **9.** $40.32. **10.** $15.06.

Page **54**—**1.** 5.196 +. 29,875. 79.84 +. **3.** 9.472. .799. 54.531. 4,242.

Page **56**—**2.** 1.4 ft. 4.8 ft. **3.** 6.3 ft. **4.** 18 ft. **5.** $\frac{5}{1\frac{3}{7}}$. **6.** 7.07. **9.** 369. **10.** 1,506.

Page **57**—**11.** 20.8—. **1.** 480. 204 ft. 117 ft. $195\frac{1}{2}$ ft. **2.** $\frac{3}{4}$ acre.

Page **58**—**1.** $6\frac{1}{4}$ acres. **2.** 21,952. **3.** 70 acres. **4.** 201.8 acres. 338.2 acres. 355.4 + rds. **5.** $247\frac{1}{2}$ acres.

Page **59**—**1.** $6\frac{1}{4}$. **2.** 380 and 260. **3.** 70. **4.** 193.2 and 446.8 355.4 rods. **5.** 247.5.

Page **60**—**4.** 11.8. **5.** 3 in. nearly.

Page **61**—**6.** 31.68 in. too large. **1.** 154. 452.5. 50.2. 346.5. 452.5.

Page **62**—**2.** 103.1. 658.7. **3.** 346.5. **4.** .314. **5.** 4 times. **6.** 9, 16, 25. **7.** 5 in. **8.** 10.7 + in.

Page **63**—**2.** 53.9 bbls. **3.** 4,620 cu. ft.

Page **64**—**4.** 32.8 cu. ft., 2,118 cu. ft., 12.3 ft. waste. .37 of log. **5.** 1,202 gal.

Page **65**—**1.** 100 bu. approximately. **3.** 109 bu. approximately.

Page **67**—**1.** 54 lbs. **2.** 315.67 lbs. $89.97. **5.** 25.1 tons. $23.04. **6.** 37.5 lbs. 3,750.

Page **68**—**3.** $43\frac{3}{4}\%$. $2\frac{1}{7}$. **4.** 8%. **5.** 87.7%.

Page **69**—**3.** $25,000. **4.** $276.64 + beef value. **5.** $9,000. **6.** $12,800.

Page **70**—**2.** $28. **3.** $26. **4.** $259.67. **5.** $153.12. **6.** $45. **7.** $2,861.

Page **71**—**10.** $81.67. **11.** $54.14. **12.** $104.20. **13.** $82.40. **14.** $87.48. **15.** $36.33. **1.** 10%. $108.04. **2.** The latter. $27. **3.** $953.34. **4.** 36.02%. **5.** $282.

Page **72**—**6.** $1.57. **7.** $323.80. **8.** $65 for beef.

Page **73**—**4.** $\frac{4}{5}$, $\frac{4}{1}$, $\frac{1}{16}$.

Page **74**—**6.** $\frac{1}{3}$, **7.** $\frac{1}{16}$, $\frac{1}{5}$. **8.** $\frac{1}{4}$. **9.** $\frac{25}{49}$. **11.** $\frac{1}{8}$, $\frac{1}{27}$. **12.** $\frac{1}{8}$. **13.** $\frac{1}{64}$, $1\frac{1}{25}$, $2\frac{1}{16}$. **14.** 720 ft. **15,** 8 to 1.

Page **75**—**16.** 8 cu. ft. **17.** 5.09 ft. **18.** 40.56. **19.** 500 bu. 1,000 bu. **20.** 1,218, 1,624. **21.** 16 and 32. **22.** 30 ft., 18 ft. **23.** $3\frac{3}{8}$ times. **24.** $\frac{7}{5}$. **25.** The latter. 69+ c. 29c.

PART II

Page **79**—**1.** 23.12 bu. **3.** 67.86%. **4.** $1,690,868,708.00. **5.** 210.96% greater. **6.** 46.03% increase.

Page **80**—(a). 15.96% decrease. **7.** 46.34% increase. **8.** 191,140,000 bu. **10.** 1,370,800 bales. **11.** 729,150 bales.

Page **81**—**12.** $2,425.00. **13.** $3\frac{1}{2}$ bu. and 1 bu. **14**(a). 13.44 sq. ft. (b). 3,240. (c). About 4 qts., allowing a little for overrun. 7 lbs. (d). About $3\frac{3}{4}$ bu., or 210 lbs. **15.** About 5.8 qts., or 10 lbs. **16.** About 14 to 16. **17.** About 20.5 to 24.

Page **82**—**18**(a). 47.520. (b). About 19 qts., or $33\frac{1}{4}$ lbs. (c). Between 67 and 80. **19.** 47.6 bu. **20**(a). About 5 qts., 8.75 lbs., or 18 to 20 ears. (b). 3.4 tons. **21.** About 100. **22.** $25. **23.** 60c. **24.** $2.08 less.

Page **83**—**25.** 20.5%. **25**(a). 50.3 + cents. **26.** 3.12 qts. (a). 201+ gal. **27.** 27.8 tons.

Page **84**—(a). About 14 tons. (b). About 10.5 tons. **28.** 83.3 bu.

Page 86—1. 196,481,000, valued at $4,740,684,000.00. **2.** 54 yrs. 10 mo. 12 da.

Page 87—3. $24.26. **4.** Horses, $105.05; mules, $124.80. **5.** Swine, $6.86; sheep, $4.42. **7.** 745.2. **8.** 7.9 oz. **9(a).** 17,559 lbs.; 48.1 lbs. per day. (b). 1,175.46 lbs. 3.22 lbs. per day. **10.** 23,000 lbs., averaging 63 + lbs. per day. **11.** $764.57.

Page 88—12. 14.4 lbs. **13(a).** $669.82. (b). 65.8 lbs., or 30.6 qts.

Page 89—13(c). 25 lbs. **14(a).** 4.53%. (b). 7.8+ gal.

15.	Fat per yr.	Fat per day	Milk per yr.
May Rilma	1073.17 lbs.	2.93 lbs.	19673 lbs.
Murne Cowan	1097.16 lbs.	3 lbs.	24008 lbs.
Finderne Holingen Fayne	1116.05 lbs.	3.05 lbs.	24612.8 lbs.

Page 90—16(a). 83.4 lbs., or 38.8 qts. (b). 3.12%.

Page 92—1. 60 lbs., 344 lbs., 284 lbs., 216 lbs., respectively. **2.** 522 lbs.

Page 93—3. 3.53⅓%. Alfalfa. Protein required for milk production. 71.1%. 61.2%. **4.** 60 lbs. more in alfalfa. **5.** 1.48+. **6(a).** 22.4 lbs. **6(b).** 794.08 lbs. **6(c).** 816.48 lbs. **6(d).** 759.36 lbs. **7.** Only 20 lbs. more in timothy. **8.** 3.39 acres. **9.** 5.95 tons.

Page 94—10. 70 lbs. and 64.4 respectively. **11.** 27,936 lbs. and 20,992 lbs., respectively. **12.** 420 lbs. more in cottonseed meal. **13.** 48 lbs. more in bran. **14.** 1,300 lbs. in cottonseed meal, 1,142 lbs. in bran, 1,010 lbs. in alfalfa.

Page 95—15. 210 lbs. more in alfalfa. **16.** Clover, 6.1 lbs. (a). Yes. 1.3 lbs. (b). 6,030 lbs. in favor of clover. (c). 11 tons clover equivalent to 6.8 tons alfalfa. Alfalfa, 89 cents per ton cheaper, or total of $3.00 cheaper. **17.** $9.82. **18.** 508.92 lbs.

Page 96—19. 792.4 lbs. and 1.4 tons, respectively. **20.** 10.18 bu. barley; 8.6 bu. dent corn. **21.** 27.6 tons. **22(a).** 10.64 lbs. **(b).** 1.12 lbs. (c). 3.75 bu. **23(a).** 101.25 tons. (b). About 8.5 acres.

Page 97—23(c). 5,062.5 cu. ft. (d). 32.8 ft. About 38.8 ft. if silage settled 6 ft. (e). At least 30 ft. to allow for settling. (f). The 14-ft., since 750 lbs. must be fed daily. **24.** 12.3; 4.8; 9; 22.5; 20.25 acres, respectively. **25(a).** 95.2; 66.64; 76.16 tons, respectively.

Page 98—25(b). 224; 156.8; 179.2 lbs., respectively. (c). 349.35 lbs. .411 lb. (d). 1,216.5 lbs. (e). 7.3+ cents. **26(a).** 4.2; 5.3; 6.2; 5.9; 9.3 lbs., respectively, in each group. (b). 3,324 lbs. **27(a).** 1,725 bu.

Page 99—27(b). 60⅜ tons. (c). 11.5 bu

Page 100—1. 168¾ lbs. **2.** 18.56 lbs.

Page 101—3. 66 lbs. **4.** 1:4 or 1 to 4.

Page 102—6. 1:6.2. **7.** 1:4. **8.** 1:1.8 vs. 1:10.4. Soy beans. **9.** Gluten meal (1:1.8). **10.** 1:3.9 (narrow). 1:3.9 (alfalfa).

Page 103—11(a). 2.27 lbs. **(b).** 14.07 lbs. (c). .76 lb. (d). 1:7. **12(a).**

	Lbs. Protein	Lbs. Carbohydrates	Lbs. Fat
Timothy	.48	6.85	.192
Oats	.97	5.21	.38
Corn	.375	3.39	.23
Oil Meal	.302	0.32	.067
Wheat Bran	.125	0.42	.03
12(b).	2.25	16.2.	.9.

12(c). 1:8.1. **13.** 1:6 vs. 1:8 (not enough nutrients). 29.5 lbs. dry matter (not sufficient bulk).

Page 104—13(a). Better. 39 lbs. dry matter; 3.3 lbs. protein; 22 lbs. carbohydrate; 1.2 lbs. fat. **14**(a). 1:5.7. (b). No. Short on dry matter also.
15(a).

	Lbs. Protein	Lbs. Carbohydrates	Lbs. Fat
Corn Silage	0.38	5.25	24
Alfalfa	1.27	4.68	.11
Corn	0.22	2.03	.14
Cottonseed Meal	0.32	0.26	.08

(b). 47 and 4 respectively.

Page 105—15(c). 1:6.2. **16**(a). 2.32 lbs. protein; 14.2 lbs. carbohydrates; .73 lb. fat. (b). 1:6.8. (c). Very well, though 15 contains less protein in particular and is a slightly narrower ration.

Page 106—17(a). 6.3 lbs. and 4.2 lbs. respectively. (b). 1:7.5. (c). 2.5 lbs. protein; 15.4 lbs. carbohydrates; .82 lb. fat. (d). 1:6.9.

Page 107—18(a). .77 lb. .62 lb. .15 lb., respectively. (b). 4.2 lbs. (c). 1:7.2 **19**(a). 1:5.9, 1:6.3, 1:7, respectively. More protein should be fed at beginning of fattening period. (b). Protein feeds. (c). Feeds high in carbohydrates.

Page 108—20(a). About 13 lbs. middlings and 25 lbs. corn. (b). $1\frac{5}{8}$ lbs. and $3\frac{1}{8}$ lbs., respectively. $4\frac{3}{4}$ lbs. total daily. About 1.6 lbs. (c). 1,706.25 lbs. and 3,281.25 lbs., respectively. 4,987.5 lbs. **21.** 1:15.2 vs. 1:3.9. Alfalfa.

Page 109—22. $500.87. **23.** The same. **23**(a). 1:6. **24**(a). 625. (b). 50c.

Page 112—1. 20,620,497. **2.** 101.6 gal.; 1.1 qts. **3**(a). 263. (b). 122.5.

Page 113—4. 1.76c. **5.** 1.59c. **6**(a). 35.3. (b). $44\frac{1}{8}$. (c). 80%. **7**(a). 1,072.17. (b). 53.9; 2.93; 25+.

Page 114—7(c). 1,250.8. (d). $431.55. **8.** 86.9%. **9.** 3.47%. **10.** $1\frac{3}{4}$c. **11.** 35% cream.

Page 115—12. 255. **13.** 75. **14.** 235.7. (a). 1,264.3. (b). .118% **15.** 2,300. (a). 1,940 lbs., testing .212+%. **16**(a). 570+. (b). 4.114%. (c). 15.3%.

Page 116—17(a). 6,970. (b). $543.60. **18.** 1.54%. **19.** No. (23.5%).

Page 117—20(a). 16 lbs. cream, 5 lbs. milk. (c). 20%. (d). No. **(Footnote, page 113). 21.** 14.5 lbs. cream, 12 lbs. milk. **22.** 6 lbs. milk, 5.5 lbs. cream. **23.** 1.3 lbs. 3.5% milk and 1.5 lbs. 6.3%

milk. (a). 46.4 lbs. of 3.5% milk and 53.6 lbs. of 6.3%. **24.** 1.2 lbs. cream to 15 lbs. milk; 23.9 lbs. cream and 298.3 lbs. milk. **25.** 18.1 lbs.

Page 118—26. 2+; 6¾ qts. **27**(a). 2,457. (b). 1,086.75. (c). $61.90 in favor of cheese; $6.62 in favor of butter. **28**(a). 1,748 lbs. (b). 3 lbs.; 4 lbs.; 7 lbs.; 210— lbs. (c). 440.

Page 119—28(d). 4.19+%. (e). 433 per day. 4 lbs. lost in buttermilk; 3 lbs. lost in skim milk. (f). 508.8 lbs. (g). 15.63%. (h). $24.08 per day; $722.40 per mo. **29**(a). 16.4% (3 lbs. less fat received in form of cream than milk). (b). 3 lbs. less fat received. (c). $31.50 more returns per mo. when cream is brought in instead of whole milk. He pays for 3 lbs. less of cream per day, not reckoning extra machinery and labor cost involved in skimming.

Page 120—1. 43,560. **2.** 98 lbs.; 78 lbs.; 39 lbs.; 14 lbs.

Page 121—3. Approximately 357 tons less. **4.** 46.3%. 34.2%. **5.** 140%. **6.** 19, 10.6, 2.4 oz., respectively. **7.** 15.2%, 62.8%, 22%, respectively. **8.** 50,800. **9.** 48,260 less.

Page 122—11. 70,450,000 more; 1,410 times. **12.** 3,750%. **13.** 40.4. **14.** 21⅔, 45, 125, 36⅔, respectively.

Page 125—1. 504.

Page 126—1(a). 560. **2**(a). 3½ tons. (b). 11,046. (c). 113.42 approximately. (d). 13.2—. (e). 2.13 rds. (f). 152 + bbls. **(3).** 12½ inches.

Page 127—4. 8¾ inches. **5.** None. **6.** 9%. Cultivated field had mulch which hindered evaporation. **7.** 38.86 inches. **8.** 3,559.8. **9.** 639 and 2,447.1, respectively.

Page 128—10. 70.8%. **11.** 6.3lbs. **12.** Lines to represent 65 nitrogen, 3.3 phosphorus and 70.5 potassium.

Page 129—13. 78.7%. **14**(a). 40; 80; 40; 80.

Page 130—15. Further depleted by 5.95 lbs. phosphorus, 47¼ lbs. potassium and 53.9 lbs. calcium. **16.** No. 71¾ lbs. **16**(a). $10.76. (b). 71¾ lbs. **17.** 270; 41.8; 312.3 lbs., respectively. **18.** 17.67. **19.** 1,439.1 lbs. more removed from 18 acres of alfalfa and clover than from 45 acres of corn and oats.

Page 131—20(a). 303.9 lbs. phosphorus; 1,250¼ lbs. potassium; 1,620 lbs. nitrogen.

Page 133—1. 180. **2.** 4,100 lbs. **3.** .1% nitrogen; .015% phosphorus; .6% potassium. **4.** 1.005% nitrogen; .1265% phosphorus; .855% potassium.

Page 134—5. 5,000 lbs. nitrogen; 2,000 lbs. phosphorus; 40,000 lbs. potassium.

6.

Soil	Lbs. Nitrogen	Lbs. Phosphorus	Lbs. Potassium
Fertile silt or clay loam.....	5,000	2,000	40,000
A poor sand.....	2,000	500	12,500
An average peat....	10,500	420	1,050

7. 12 times, or 1,200%.

Page 135—8. 1.2. 120%. **9.** Pounds, because some soils are much heavier than others. **10.** 2,400 lbs. nitrogen; 1,140 lbs. phosphorus. **11.** Only about 49 crops.

Page 136—12. .15%. **13.** 171. **14.** 20⅔ lbs.

Page 139—1(a). 820; 68; 540 lbs., respectively. (b). 328; 13.6; 108 lbs., respectively.

Page 140—1(c). 492; 54.4; 432 lbs., respectively. **2.** 68 lbs. phosphorus; 540 lbs. potassium; no nitrogen. **3.** 8.2 lbs. nitrogen gained; 132.2 lbs. phosphorus gained; 99.2 lbs. potassium lost. **4**(a). No nitrogen; 25.5 lbs. phosphorus. (b). 184.5 lbs. nitrogen; 20.4 lbs. phosphorus. (c). Gain of 184.5 lbs. nitrogen; loss of 5.1 lbs. phosphorus. (d). Gain of 307.5 lbs. nitrogen; no increase in phosphorus.

Page 141—5(a). 151.8; 42.1; 222 lbs., respectively. (b). 91.1; 33.7; 177.6 lbs., respectively. (c). 72.7%. **6.** 274.5 and 23.5 lbs., respectively. **7.** 4,332. (a). 135.2. **8**(a). 698.4 and 61.2 respectively.

Page 142—8(b). 1,047.6 and 245 lbs., respectively. **9.** 1.19 tons. **10**(a). 50.6 lbs. gain.

Page 144—(b). 137.7 lbs. gain.

Page 145—(c). 366.7 lbs. loss of nitrogen; 154.4 lbs. loss of phosphorus; 1,187.7 lbs. (d). 134.1 lbs. nitrogen gained; 74 lbs. phosphorus gained. (e). 524 lbs. lost. (f). 954.6 lbs. loss of nitrogen; 24 lbs. loss of phosphorus; 1,780½ lbs. loss of potassium. **11.** 1,939 lbs. loss of nitrogen; 123.5 lbs. loss of phosphorus.

Page 148—1(a). 2,500; 500; 2,000 lbs., respectively.

Page 149—(b). $545. (c). $17.44. **2.** $1.85; $2.11; $2.51; $3.50; $3.82, respectively. **3.** $3.25.

Page 150—4(a). $2.51. (b). The 16-ton application produced 54.5% greater crop value. (c). The 8-ton application, 74 cents more. **5**(a). 30.3%; 24.07%; 58.96%, respectively. (b). 40.12%. (c). 83.4 cents. (d). $208.50.

Page 151—6. $94.50. (a). $304.75. (b). $31.50. **7**(a). 332; 68; 224 lbs., respectively. (b). Gain of 75.3 lbs. nitrogen, 11 lbs. phosphorus and 3.6 lbs. potassium.

Page 152—(a). Losses of 103 lbs. nitrogen, 23 lbs. phosphorus and 91 lbs. potassium. (b). Losses of 41.5 lbs. nitrogen, 18 lbs. phosphorus and 50.5 lbs. potassium. (c). An average of between 35 and 48 cows.

Page 153—1. 256⅔. **2.** 1,160.

Page 154—3. 5.34c; 6⅔c; 6¼c, respectively. **4.** About 2 qts. or 4 lbs. (a). About 13. About 4. **5.** 107.7.

Page 155—6. 14.38% P. **7.** 275.55 lbs. P. **8.** 41.5% K. **9.** 290.5 lbs. K. **10.** 1.32 lbs. P. more per $1 at $8.25. **11.** 1,062.4. **12**(a). 22 lbs. N.; 60 lbs. P.; 50 lbs. K.; (b). $12.20.

Page 156—12(c). $12.30. **13**(a). 70 lbs. N.; 72 lbs. P.; 132 lbs. K.; $27.68; $8.82. **14**(a). 21.5% K.; 3.5% P. (b). 75¼ lbs. K.; 12¼ lbs. P. (c). $5.60. (d). K. 5.34c; P. 12⅔c. (e). 3,010 lbs.; $36.87.

$24.05 saved. (The phosphorus in the mixed fertilizer is valued at $7.22. Nitrogen was not needed).

Page **157**—(f). $17.50 returned from $5.60 when corn is worth 50c per bu. (g). 75¼ lbs. K. added, 33⅓ removed; 12¼ lbs. P. added, 11.1 removed. (h). 97.4 lbs. muriate of potash mixed with 195.7 lbs. acid phosphate. **15.** 466⅔; 1,143; 300 lbs., respectively. (a). 90⅓ lbs. (b). $27.69, costing the least per 100 lbs. of fertility. **16.** 104 lbs. P.; 814 lbs. K. (a). Between 1,893 and 1,938 lbs. of muriate of potash; 1,485.7 lbs. acid phosphate.

Page **158**—**16**(b). 844.7 lbs., using 43% potash. **17**(a). 180. (b). $27. (c). 36 lbs. P.; 144 lbs. K.; $12.24.

Page **159**—(d). 334.8 lbs. potash and 450 lbs. basic slag. (e). $11.30 compared with $39.24 as value of manure.

Page **162**—**1**(a). $24.68.

Page **163**—(b). 123.4%. (c). $44.40, not counting cost of marketing. **2.** $17.55.

Page **164**—**3.** $677.08. **4.** 2,660%. **5.** $504.

Page **165**—(a). $57.14. (b). $48; $3.43. (c). $17.11. (d). 34.2c. **7.** $45.63; $21.90; $2.74 (average yearly interest); $25.36; 56.35c.

Page **166**—**8**(a). 67.7%; 22.3%. (b). $17.72. **9**(a). $9; 60c. (b). 88.5 bu. of corn; 4.5 tons of stover. (c). $5.56.

Page **167**—**9**(d). $33.75. **10**(a). $245.53. (b). $10.50. (c). $65 net; $54.50 more than (b).

Page **168**—**11.** 96.14c. **12.** 90c loss. **13.** 491⅔ and 535.7 lbs., respectively. (b). 5. **14.** $35.93 lost.

Page **169**—**14**(a). $73.42 gain. (b). 23.3—lbs. (c). $29.13 loss. **15.** .26+ lb.; 514⅔ lbs. for flock of 1,980. (b). $208.80. (c). 10.54c. (d). 154.4; 1.7+ lbs. (e). 19.

Page **170**—**16**(b). $117.65 profit.

Page **171**—**16**(c). $88.65 profit. (d). 8.74c. (e). **10**.4c. **17**(a and b).

Cow	Lbs. butter-fat	Value of fat	Net returns
1	139.2	$41.76	$1.24 loss
2	429.6	128.88	68.88
3	221.2	66.36	16.36
4	362.7	108.81	53.81
5	149.5	44.85	0.85
6	75.4	22.62	20.38 loss
7	314.0	94.20	44.20
8	127.9	38.37	6.63 loss
9	261.2	78.36	26.36
10	289.8	86.94	34.94

(c). $217.15; $21.72.

Page **172**(a)—(d). $201.83 or $186.51 more than from the remaining six. (e). Between 13 and 14. (f). 81. (g). $440.85 or $223.70 more than when these four cows were kept.

Page **173**—(h). $317.95.

18(a).

	Star	Nig
Value of fat in cream	$107.81	$52.12
Amount skim milk	8,825	4,976
Value skim milk	$13.23	$7.46

(b). Nig caused a loss of $11.18, hence she is worth more for beef. $239.15, true value of Star.

Page **174**—**19**(a). 338.8%.

Page **175**—**20**(a). 123.6 lbs. valued at $18.54. (b). $17.53. **21**(a). 32.76 lbs. P.; 14.9 lbs. K.; 20.8 lbs. N. (b). $7.30. (c). $47.90.

Page **176**—(a). $32.70. (b). $3.53. (c). $2.43. (d). $4 or 17.7% loss when manure is valued at $1.50 per ton, and $14, or 42.8% loss when valued at $2.18 per ton. (e). $14.60. (f). 61c. (g). 228.08% (h). 45.4c.; 340.2%; $1.98 less than on strip No. 1 when manure is valued at $1.50 per ton, and 15.6c. less than on strip No. 2.

Page **177**—(j). Strip No. 2; $2 or 6.4% greater profits per acre when other costs remain the same. (k). No. 2, $1.65 or 5.3% greater profits per acre. **23**(a). $9.84; 21.8c.; 15.1c.

Page **178**—(b). 28 bu. (c). $17.59. (d). 51.73 bu. (e). 92c loss, 80c profit per acre; $1.25 profit.

Page **179**—**24**(a). "A," 214.1% profit; "B," 56.2%. (b). "A" realizes 281% more profit than "B" (per cent on fertilizer cost not included). **25**(a). Jones realized 250% profit as compared with 200% by Brown. (b). Brown gained $225 more than Jones, other conditions remaining the same. Jones 226% profit, Brown, 176%; Brown's investment more profitable by $189.00.

Page **180**—**25**(d). More profitable by $75; $111. **26**(a). $53.72. (b). $1,074.50. (c). $525. (e). $1,321.60 when producing cost remains the same.

Page **182**—(b). $7.27.

Page **183**—**30**(a). $967.51. (b). $80.62. (c). 28.4c.

Page **185**—(a). $265.14. (b). $80.39. (c). $116.49. (d). $143. **32.** $640.40. **33.** $318.22. **34.** $537.50. **35.** 250%.

Page **186**—**36**(a). A 316⅔% increase in capital gives a 262.5% increase in labor income. (b). $390; $1,495. **37**(a). 62.6%; 55.5%. (b). 14.6%; 7.1—%. (c). 22.8%; 37.3%. (d). $2,258.50; "B" received no labor or managerial income, since he realized only 3.8% profit on his investment. (e). "B" has too large a proportion of "fixed" capital.

Page **187**—**38**(a). 39.8% more profitable, other conditions being equal. (b). 26.4%. **39.** $254. **40.** $424.

Page **188**—(a). $16,486.00. (b). $5,438.80. (c). $2,418.00. (d). $3,020.00. (e). $824.30. (f). $2,195.70.

Page **189**—**1.** 80; 40; 10 acres, respectively.

Page **191**—**7**(b). 2.25 acres.

Page **192**—**8**(b). 1.2 acres. **9**(a). 2.8 acres. **10**(b). 2.04 acres.

Page **193**—**10**(c). About 95 rds. (Use thread to measure). **11.** 9.03 acres, approximately. **12**(a). (1) 12.7 acres; (2) 14.76 acres; (3) 11.7 acres; (4) 11.25 acres; (5) 2.5 acres; (6) 10.9 acres; (7) 10.9 acres; (8) About 5.7 acres. (b). (1) 205 rds.; (2) 205 rds.; (3) 190 rds.; (4) 163.75 rds.; (5) 80 rds.; (6) 170 rds.; (7) 170 rds.; (8) 102.5 rds. (c). 933¾ rds. **13**(a). $174.37. (b). 194.8%.

Page **194**—**14.** $268.08.

Page **197**—**15.** 25.92; 27.77; 23.32, respectively. **17.** 7.56 tons. **18.** $10. **19.** 15.6 tons.

Page **199**—**22.** $80.88. **23.** 6.8 tons. **24.** 3,214.2 bu. **25.** 1,768 bu.; 23.8 tons more of water.

Page **200**—**26.** 540 bu. (quick calculation); 32c. per bu. **27.** 2,250 bu. (quick calculation). **28.** $394.66 (short method). **29.** 937.5 baskets (heaped) or 625 bu. (shelled). **30.** 49.4 bbls. **31.** 7.48 gal. **32.** 8.77 ft. **33.** 2 rds. apart each way. (b). 90 lbs. (c). 4.

Page **201**—**34.** 33.13 acres. **35.** 314. **36.** 600 bu.; 9.6 tons; 14.5; 18 (short method). **37.** 10 of sand, 5 of cement. **38.** 3½ cu. ft. sand, 7 cu. ft. gravel; 10½ cu. ft. sand, 21 cu. ft. gravel.

Page **202**—**39.** 11.4 cu. ft. sand, 22.8 cu. ft. stone. **40.** 8.8 bbls.; 3.1 cu. yds.; 6.2 cu. yds., respectively. **41.** 50.5 bbls. cement, 14.2 cu. yds. sand, 28.4 cu. yds. gravel. **42.** About 2 bags cement, 4.6 cu. ft. sand and 9.2 cu ft. gravel. **43.** One of at least 120-ton capacity, and should be 16 ft. in diameter and about 35 ft. deep (allowing a few feet for settling of silage).

Page **203**—(a). 33 bbls. cement, 11 cu. yds. sand, 22 cu. yds. gravel or crushed stone.

Page **206**—**1.** 48 to 108; 108 to 170; 69 to 170, respectively. **2.** 33. **3.** 25 more.

Page **207**—**3**(b). 58. **4.** 40; about 70. **5**(a). 3 more. (b). 31.1 feet. **6.** 160; 280; 184, respectively. **7.** 28 lbs. of each material.

Page **208**—**8.** 6⅔ lbs. soap and 26⅔ gal. kerosene for summer spraying; 13.8 lbs. soap and 55.4 gal. kerosene for winter spraying. **9**(a). $708.21. (b). $1,123.54. (c). $236.07; $374.51.

Page **209**—(d). 12.48%; 44.06%. **10**(c). $8.59; $233.76.

Page **210**—**11**(a). 93.2c; $108.86. (b). $3.55 per tree; $96.65 per acre. (c). $121.65 (net income includes interest on investment); 24.33%. **12.** 1.6 bu. (a). ½ oz. of formalin in one gallon of water. (b). $\frac{1}{10}$ lb. Paris green and $\frac{3}{10}$ lb. lime and 5 gal. water.

Page **211**—**12**(c). ½ lb. blue vitriol and ½ lb. lime. **13**(a). $76.55. (b). $42.68. (c). ½ acre.

Page **212**—(d). 352 bu. (e). 700.2 bu.; $997.78.

Page **215**—**1**(a). 36.5%; 63.4%, respectively. (b). $89.58. (c). 25.9% less; 35% greater. **2.** 51.7%. **3.** 27.8c. **4.** 24c.

Page **216**—**8.** 11.06 lbs. at 27c. per lb. **9.** 7.03 bu. **10.** 67.7 gal.

Page **217**—**12.** 12.68 lbs. **13.** .9 lb. more in the bananas. **14.** ¼ oz. in favor of meat (11 lbs. eggs). **15.** The cheese, 2.3 lbs. more than beef and 3.6 lbs. more than veal.

Page **218**—**17.** 1.1 lbs. or about 10 eggs, 5.6 oz. cheese, 10 oz. ham, 4 oz. peanuts, 1.5 lbs. potatoes, 2.4 lbs. apples, 4 oz. wheat bread. **18.** 95.8%; 12.8%. **19**(a). Total of .16 lb. protein, 1.03 lbs. carbohydrates, .2 lb. fat. **20.** 5.1% more protein, 25% more ash.

Page **219**—**21.** 144.3% more. **22.** .06 lb. nutrients to be supplied by 1 + oz. grapenuts. (a). 4¾c. and 7 + c., respectively.

Page **220**—**24**(b). 3.1 lbs.; 2.46 lbs., respectively. (c). 1:10.9 and 1:7.1, respectively. (e). .06 lb. and .06, respectively.

Page **221**—**1.** 1,680.4 sq. ft. **2.** 9 + c. on a dollar. **3.** $1,800.00. (a). $163.35. **4.** About 56.5 rds.

Page **222**—(a). About 28 rds. **5.** 126.5 times or 12,650% more. **6.** Between 34,700 and 69,400 per min. **8.** From .04% to .0467%.

Page **223**—**9.** $1,920.00; $160. **10.** About 3.9 lbs. **11.** 15 bu. **11**(a). $11.26.

Page **224**—**11**(b). 81 bu. (c). $11.26 or $61.30 per acre. (d). 75c. per bu. in feeding. **12.** About ½ oz. soap and 6 pts. kerosene for summer, and about .6 oz. soap and 1.2 pts. kerosene for winter spraying. **13.** .8 lb. each of blue vitriol and lime. **14.** $288.90. (a). $182.97. **15.** 17,191 ft.

Page **225**—**16.** About 14. (a). 8.8 mo.

Page **226**—**17**(a). $534.59. (b). $1,458.87 total for year. (c). 67,757 eggs; nearly 112 per fowl; $2.43. (d). $602.28; practically $1 per fowl. (e). $1,100 at 6%. **18.** Cotton, 40 oz. more. **19.** $54.75 spent foolishly. **20.** 16.4 + %. (a). $575; $479.16. **21.** 2 lbs. more phosphorus may be purchased per dollar at $9 per ton.

Page **227**—**22.** One part. **23.** .057. **24.** 160. (a). 155,040. (b). 22%. **25.** 21.3 gal. (a). 3.4 bbl. **26.** There would be but little difference.

Page **228**—**27.** 4.15%. (a). 60.42 lbs. (b). 1,384.08 lbs. valued at $415.22; $48.96 (30% cream considered drawn); $464.18.

Page **229**—(c). 4 +. **28.** 100% more. **29.** 48.3%; 59.3% red clover; 71.1%. **30.** $38.35. **31.** .94 and 1.35 tons respectively; 43.6% increase. **32.** No, $4.81 loss per acre per year. (Clover considered as not reducing nitrogen content of soil.)

Page **230**—**33.** About 264 lbs. loss of nitrogen, 114 lbs. phosphorus and 398 lbs. potassium. (Oat straw used for bedding.)

Page **231**—(a). About 13; 5; 15.

Page **232**—**35**(a). 2% N., 5.2% P., 6.6% K., 40 lbs. N., 104 lbs. P., 132.8 lbs. K. (b). 179.5% and 245% profits, respectively. (c). Man of small means can get greater per cent on his limited money when he applies 600 lbs. per acre; whereas a man of ample means can realize more net returns per acre when he applies 1,200 lbs. per acre. (d). $9.23 more profitable per acre (other conditions remaining the same).

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Answers in 1916 edition should read as follows:

Page	Prob.	Answer
31	1	$1,890
31	2	$1,100
37	4	282 cu. ft.
37	6	28.5 bbls.
37	9	$189
37	13	6 inches
38	17	11 tons
		10 tons
38	19	10.8 inches
40	10	$11.28
40	11	$15.58
40	12	430.05 sq.rd.
41	7	2.68+ acres
41	8	191.1
53	10	$15.84
56	4	18.02 ft.
56	5	5.29/12 or 5/12+
65	3	140 bu.
		157 bu.
		Approx.
68	5	86 2/3%
70	3	$28.62
71	1	10%, $1.08
72	6	$1.60
72	7	$354.43
79	5	210.27% greater
82	18(a)	47,520
93	3	353 1/3%, 71.1%, 48.4%
95	18	528.92 lbs.
112	2	101.06 gal.
112	3(a)	261.3 gal.
115	15(a)	1,940 lbs. testing .103+%
130	18	17.475
135	8	2.1, 210%
141	5(a)	336.4
141	5(b)	201.84
		33.68, 177.6 resp.
144	(b)	138.7 lbs. gain
164	4	2646.5%
166	9(b)	90 bu. of corn
166	9(c)	$5.63
167	9(d)	$34.50
168	11	96.3¢
169	14(c)	$28.64 loss
202	40	8.88 bbls.
219	22(a)	4¾¢ and 7¢+ resp.
221	2	9¢+ on a dollar