COUNTING IN DOZENS

1	2	3	4	5	6	7	8	9	X	Ɛ	10
one	two	three	four	five	six	seven	eight	nine	dek	el	do

Our common number system is decimal - based on ten. The dozen system uses twelve as the base, which is written *10*, and is called *do*, for dozen. The quantity *one gross* is written *100*, and is called *gro*. *1000* is called *mo*, representing the meg-gross, or great-gross.

In our customary counting, the places in our numbers represent successive powers of ten; that is, in 365, the 5 applies to units, the 6 applies to tens, and the 3 applies to tens-of-tens, or hundreds. Place value is even more important in dozenal counting. For example, *265* represents *5* units, *6* dozen, and *2* dozen-dozen, or gross. This number would be called *2 gro 6 do 5*, and by a coincidence, represents the same quantity normally expressed as 365.

Place value is the whole key to dozenal arithmetic. Observe the following additions, remembering that we add up to a dozen before carrying one.

94	136	Five ft. nine in.	5.9'
31	694	Three ft. two in.	3.2'
96	3Ɛ2	Two ft. eight in.	2.8'
19Ɛ	1000	Eleven ft. seven in.	Ɛ.7'

You will not have to learn the dozenal multiplication tables since you already know the 12-times table. Mentally convert the quantities into dozens, and set them down. For example, 7 times 9 is 63, *which is* 5 dozen and 3; so set down *53*. Using this "*which is*" step, you will be able to multiply and divide dozenal numbers without referring to the dozenal multiplication table.

Conversion of small quantities is obvious. By simple inspection, if you are 35 years old, dozenally you are only *2Ɛ*, which is two dozen and eleven. For larger numbers, keep dividing by 12, and the successive remainders are the desired dozenal numbers.

12) 365
12) 30 + 5
12) 2 + 6
0 + 2 Answer: *265*

Dozenal numbers may be converted to decimal numbers by setting down the units figure, adding to it 12 times the second figure, plus 12^2 (or 144) times the third figure, plus 12^3 (or 1728) times the fourth figure, and so on as far as needed. Or, to use a method corresponding to the illustration, keep dividing by X, and the successive remainders are the desired decimal number.

Fractions may be similarly converted by using successive multiplications, instead of divisions, by 12 or X.

Numerical Progression

1	One		
10	Do	.1	Edo
100	Gro	.01	Egro
1,000	Mo	.001	Emo
10,000	Do-mo	.000,1	Edo-mo
100,000	Gro-mo	.000,01	Egro-mo
1,000,000	Bi-mo	.000,001	Ebi-mo
1,000,000,000	Tri-mo	and so on.	

Multiplication Table

1	2	3	4	5	6	7	8	9	X	Ɛ
2	4	6	8	X	10	12	14	16	18	1X
3	6	9	10	13	16	19	20	23	26	29
4	8	10	14	18	20	24	28	30	34	38
5	X	13	18	21	26	2Ɛ	34	39	42	47
6	10	16	20	26	30	36	40	46	50	56
7	12	19	24	2Ɛ	36	41	48	53	5X	65
8	14	20	28	34	40	48	54	60	68	74
9	16	23	30	39	46	53	60	69	76	83
X	18	26	34	42	50	5X	68	76	84	92
Ɛ	1X	29	38	47	56	65	74	83	92	X1

The Duodecimal Bulletin

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THE DUODECIMAL SOCIETY OF AMERICA

20 Carlton Place ~ ~ ~ ~ ~ Staten Island 4, N. Y.

THE DUODECIMAL SOCIETY OF AMERICA

is a voluntary nonprofit organization for the conduct of research and education of the public in the use of Base Twelve in numeration, mathematics, weights and measures, and other branches of pure and applied science.

Full membership with voting privileges requires the passing of elementary tests in the performance of twelve-base arithmetic. The lessons and examinations are free to those whose entrance applications are accepted. Remittance of $6, covering initiation fee ($3) and one year's dues ($3), must accompany applications.

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The Duodecimal Bulletin

All figures in italics are duodecimal.

PROPOSAL FOR A NEW METRIC SYSTEM
by I. V. Colonna Valevski*

From the dawn of history man knew how to count. He counted the days, he recorded the seasons, he used his fingers, his hands, his feet, and the length of his stride for measurements, and he understood measurement by weight and volume.

But all this was spontaneous and without any system or order. An early attempt to introduce order into this chaos was made in ancient Babylon. A system based on 60 had come into use. It comprised measurement of length, weight, money, time and angle. For 35 centuries this monument to ancient thought was never surpassed. Through the Arabs, who modified and developed it further, this ancient system was handed down to us. They used fractions on the 60-base (minutes, seconds, etc.), not for time and angle only, but for fractions of any unit. Later, they introduced us to the decimal number script which has come into general use.

But measurement became confused by conflicting standards. Every country, nay every small city and township had its own set of measures, and these had very little in common. A rational system became imperative.

The Metric System, introduced by Napoleon's decree of 1799, was one such solution. It comprised length, volume and capacity, weight and money. It offered two apparent advantages, - internationality, and a natural basis for a standard of length. While it was soon proven that the calculation of this length standard was not precise, yet to change the announced length of the meter was not convenient, and it was continued as an arbitrary value.

Progressively, many nations accepted the metric system, but it was not accepted by Britain nor by the U. S. And chiefly because the decimal division was not as convenient as that permitting division by 3; so they would not abandon the foot (12 inches), or the shilling (12 pence).

Thus it was originally; soon other defects were found. The centigrade thermometer was accepted as part of the system. Normal atmospheric pressure was stated as 760 mm. of the barometric column; i.e., as 1.033 kilograms per square

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*Copyright is reserved by I. V. Colonna Valevski, Rancagua 023, Santiago, Chile, who had no knowledge of our Society, nor of the works of its members, when he wrote the original Esperanto text of this article, which, in translation, has been somewhat edited and curtailed.

centimeter. Only then water boils at 100°C. If, alternatively, exactly 1 kilogram per square centimeter had been adopted, then water would boil at 99.1°C. Moreover, many countries have negative (i.e., below-zero) temperatures in winter; for that reason the Fahrenheit scale, whose zero is lower, is preferred there. Ultimately, it was determined that absolute zero was -273.16°C, which is neither -300°, nor -250°, nor even -275° or -273°.

The development of thermodynamics introduced measures of energy which became as important as measures of length or of weight. And for the different types of energy different units were used, namely: joules, kilogram-meters, calories, watt-hours, etc. And the relations between them were very complex, as can be seen from the following table.

joules		kilogram-meters		calories		
1.	=	0.10179	=	0.23912		
9.80665	=	1.	=	2.345		
4.182	=	0.4265	=	1.		
101.325	=	10.3323	=	24.229	=	1 lit. atm.
3600	=	367.098	=	860.83	=	1 watt-hr.

These intricacies ensue from the values of 1.033 for the atmospheric pressure, and of 980.665 for the acceleration by gravity.

The modern practice of defining length standards in wave-lengths of light has introduced another set of figures, unconformable to the metric system. The meter is defined as 1 553 164.15 wave-lengths of the red line of cadmium. This is not 1 553 160 exactly, nor even 1 553 164. It is evident that the metric system is not actually natural, - but arbitrary, inconvenient, and unfit to be the international standard. Thus it is our duty to find the way to eliminate these dissonances.

How could we correct this? If we were to take a new length for the meter of 97.97 cm., i.e., 1 521 625 cadmium red wavelengths, and 992 2/3 grams as a unit of mass, we would have a value for the acceleration by gravity of 10 meters per second per second, and an atmospheric pressure of 1 kilogram per square centimeter. Consequently, the kilogram-meter would equal 10 joules and the liter-atmosphere would equal 10 kilogram-meters or 100 joules. Very well. With some new temperature scale, we could have a calorie, not equal to 4.182 joules, but to 4 joules exactly; or - better still - to 1 joule or 10 joules. But what about the watt-hour? For it we would have to divide the day-night

into 10, 20, or perhaps 25 hours, so that it would be 100 000 seconds instead of 86 400. And we would have to change every clock accordingly. Would this be possible? It is more than certain that at least three-fourths of the people would refuse to give up their old clocks and watches, even though they were able to exchange them for new equal, or more valuable ones. We would be involved not only with simple conservatism, but the part played by traditionally sacred, heart-touching, patriotic memories, - a sort of fetishism, despite the exclusion of any racial factor. This is the obstinate obstacle we would have to overcome.

Similarly, with some decimal division of angle, we would be able to express in whole numbers the values of those very natural angles of 30 and 60 degrees. Hence, we will have to agree that this convenient reform is not possible as long as we retain the number "ten" as our base. Shall we then drop the improvement of the whole system for so weak a reason?

But all of this becomes different, if we question, not the superstructure, but the number base itself. Do we truly have to be bound by it? What, if any, special qualifications does it have? The fact is, only, that we have ten fingers and that helps some people to figure. But, primarily, in our age, that is not so important because we are able to calculate better in other ways.

If we changed our base to "twelve", all of these desirable changes become easy, and we can then avail ourselves of advantages that have long been recognized. We would have to add only two new figures: Χ for dek, and Ɛ for elf, or eleven. *10* then becomes "duz" or dozen, *100* is the gross, and *1 000* is the "mios" or great-gross. The mios-mios would be the *1 000 000* ~~or "mirrod"~~, followed by ~~the biriod,~~ the tririod, etc., as the successive 3-figure multiples by periods.

Good

~~tririod~~ bios, trios, quartos, quintos, etc

Is this objectionable? Certainly not. We would have to learn the multiplication-table of twelves, but we already do that. All calculation becomes easier, more fractions come out even, and more factors are indicated by their familiar endings. All primes end in *1, 5, 7, or Ɛ.* The most-used constants and operators are simplified and improved as follows: √2 = *1.5*; √3 = *1.895*; √5 = 2.*2Χ*; the golden proportion = *.75*; *10 001* = *75* · *175*; *1 001* = *7* · *11* · *17*; *101* = *5* · *25*; π = *3.184 809*; lg π = *0.564 063*; e = *2.875 236*; lg e = *0.49Ɛ 494*; ln 2 = *0.839 912*; ln *10* = 2.*599 Ɛ03*;

1000 Mios (one great Gross)
1,000,000 Bios (two groups of 000)
10^9 Trios
10^{12} Quartos

lg 2 = 0.342 01Ɛ; ln 3 = 1.122 49Ɛ; lg 3 = 0.537 Ɛ82; π^2 = 9.𝒳52 815; with four figures we state double the quantity; with six, triple.

Then why has no one ever proposed it? But many have, - among them Laplace, Herbert Spencer, Lancelot Hogben, H. G. Wells, and, more recently, E. C. T. Werner, a British ex-consul, whose duodecimal proposal is titled, "The Ill-Made Metric System". We agree that the time has now come to plead for it. Nature shows that the dozen base is truly better fitted for calculation. But what about the system of measurement? We shall see.

See 8

First let us consider angles. Remember that there is the inescapable angular unit, the radian, 180°/π. And that the most frequent natural angles are 30°, 45°, and 60°, or in radians, $\pi/6$, $\pi/4$, and $\pi/3$. The common factor of the three is 15° or $\pi/12$. Here then is our basic unit angle. And as to time, 15° corresponds to one hour's rotation of the earth on its axis. So we divide it into 144 minutes, and these in turn into 144 seconds, as follows:

	π	$\pi/12$	$\pi/12^2$	$\pi/12^3$	$\pi/12^4$	$\pi/12^5$
time —	12 hr.	1 hr.	5 min.	25 sec.	2 1/12 sec.	25/144 sec.
arc —	180°	15°	1¼°	6¼ min.	31¼ sec.	2.604 sec.
time —	half-day	hour	grad	minute		second

So, 25/144 (or .17361̇) second will be our new second.

Let us choose our unit of length, - not directly - but by derivation from the acceleration by gravity. Since this acceleration varies with the latitude, we will select the average value as 979.7703 cm/sec^2, which for our new second would establish a length of 29.531 07 cm.

Defining this length in wavelengths, we arrive at 458 666 waves of the cadmium red line, or 580 654.8 of the green. Stated duodecimally, these are 1𝒳1 522 and 240 03𝒳.99. Preferably, these should be rounded to 1𝒳1 522 and 240 000, which makes the length unit precisely 29, 528 69 cm., or 11.625 468 5 inches, (about 11 5/8"). Until this is given an international name, we will call this the new foot. (There has been use of the green line of mercury$_{198}$ for defining length standards, and of the yellow-green line of krypton. But the decision of exact definition of this length standard may be deferred for the present.) This length would correspond to the acceleration by gravity for latitude 34° 40'.

(Mt. Wilson Obs. = 34° 13' nearly)

The duodecimal subdivisions and multiples of this new foot would be:

	Subdivisions	Multiples	
.1	2.4607 cm. (inch)	3.5434 m. (11 5/8 yd.)	10
.01	2.0506 mm. (line)	42.521 m.	100
.001	170.884 microns (point)	510.255 m.	1000
.0001	14.2403 microns	6.123 km.	10,000
.00001	1.1867 micron	43.477 km.	100,000

Mass, Force and Energy

Shall we elect mass or force as the foundation of our structure? Neither, but the pressure of the atmosphere. At normal, this would be 31 inches of the barometric column (762.825 mm.), at 65.33°F. (18.516°C.), and average gravitation. This would be stated as 1.0336 kg/cm^2. Our standard of mass, then, is a quantity of mercury in a column 762.825 mm. high and of base area of 871.94 cm^2, or the mass of 901.253 kg. This mass would properly be the ton, but we will take 1/1728 of it, or 521.559 grams (18.4 English ounces).

The force and weight units logically have to be its weight at normal acceleration by gravity: 0.521 04 kg. or 510 966 dynes. what about density; sp. gravity; wt.; vol. ?

Combining length and force units, we have the basic unit for energy: 1.508 82 joules, or 0.153 856 kgm., which is equivalent to 0.360 788 calories. 1728 times this is 623.442 calories. Because of the importance of these units, a table follows:

8 731.58 ergs	8.903 73 gcm.	0.000 208 79 cal.	
104 778.9 "	106.844 7 gcm.	0.002 505 47 "	0.002 910 53 mwh.
1.257 347 M-erg.	1.282 137 kgcm.	0.030 065 7 "	0.034 926 3 "
1.508 817 joules	0.153 856 48 kgm.	0.360 788 "	0.419 116 "
18.105 80 "	1.846 278 "	4.329 46 "	5.029 39 "
217.270 "	22.155 3 "	51.953 5 "	60.352 7 "
2.607 235 kj.	265.864 "	623.442 05 "	724.232 "
31.286 8 "	3.190 37 Tm.	7.481 305 cal.	8.690 784 wh.
375.442 "	38.284 4 "	89.775 7 "	104.289 4 "
4.505 38 mj.	459.413 "	1.077 308 Term.	1.251 473 kwh.
54.063 6 ""	5.512 96 Tkm	12.927 69 "	15.017 674 "
648.764 "	66.155 5 "	155.132 3 "	180.212 09 "

The unit of power, in fact also appears above: 8.690 8 watts, times 1728, equals 15.017 7 kilowatts, or 20.418 horsepower.

Thermometer

We have to choose whether to base our thermometry on temperature, or on heat units. We will do the latter, as more nearly ideal, and select the heat capacity of helium as our standard. In consequence, our degree equals 1.585 2°C. or 2.853 4°F. Measuring from absolute-zero, the first gross of degrees (*100*) coincides with -44.9°C., and the second with 183.37°C. For example, *134°* would correspond with 18.516°C., or 65.329°F. This would be used as the normal standard temperature for research. where is freezing?

Electrical Units

Dynamics, rather than statics, have been chosen as the base for these units, using the law of Bio-Savar. Electric current has the dimension $\sqrt{F}$, where F is force. For this reason, we earlier chose the unit of force as 510 966 dynes, and the unit of current would be 714.75 c.g.s.m. units, or 7 147.5 amperes. But our graduations will represent 1/20 736 of this, or 0.344 724 amp. We already have the power unit of 8.690 8 watts, and the rest is simple.

The unit of	quantity	0.059 848	coulomb
	potential	25.211	volts
	resistance	73.133 5	ohms
	capacitance	2.373 9	millifarads
	inductance	12.696 8	henries

To summarize the proposal, the following is a list of our other units.

length	29.528 689 4	cm.	velocity	1.700 852 5	m/sec.
area	871.943 5	cm^2.	or	6.125 069	km/hr.
volume	25.747 35	liters	acceleration	979.691	cm/sec^2.
mass	901.253	kg.	temperature	1.525 2	°C.
and	521.559	g.	or	2.853 4	°F.
energy	1.508 817	joules	and	2.607 235	kj.
or	0.153 856	kgm.	or	265.864	kgm.
or	0.360 788	calories		623.442	cal.
potenty	15.017 674	kw.	or	20.418 127	hp.

A new system cannot be introduced in a few days. It will take time and devoted effort. But the advantages it will bring require that the effort be made. A new, unified mankind needs a system of count, measure, weight, angle and time, for use throughout the world.

LEWIS CARL SEELBACH

1884 - 1958

Lewis Carl Seelbach died of a heart attack on Tuesday, September 30th, 1958, at the Meyer Memorial Hospital, Buffalo, N.Y. Masonic services were held, Thursday, by the Occidental Lodge, F. & A. M., of which he was a life member.

The Duodecimal Society mourns his loss. He joined the Society as an Aspirant in December, 1944, the year in which it was formally incorporated, and completed his tests under our revered F. Howard Seely. Their correspondence was brightened by many flashes of the quirky humor in which both were so rich.

Professionally, Carl was a Certified Public Accountant, an alumnus of Pace Institute. In 1954 he retired from his position as Staff Accountant for the City of Buffalo. But his fine mind roamed the whole world of learning, and was most engrossed in languages, and the forms and formations of words. He was an accomplished Esperantist, and corresponded with friends of many nationalities in this international tongue.

He loved to play with words. His letters were full of anagrams and acrostics with hilarious connotations. Their envelopes would be distended by packets of clippings about every conceivable subject.

Carl had never married. He lived a secluded and lonely life. But his mind knew no barriers, and when he found a congenial atmosphere his conversation would scintillate with novel ideas and atrocious puns. He was deeply religious. His creative idealism found outlets in a deep affection for the Cathedral of St. John the Divine and the symbolism of its design; - in the fashioning of an Aramaic version of the Lord's Prayer into an illuminated scroll, arranged to display its title in a vertical acrostic in its center; - in designing a "Globanner" or "Oriflamme" for the United Nations; - in unending advocacy of One World and federal world government; - and in duodecimals.

Promotion of the advantages of the twelve-base, and the weights and measures of the dozen system, became his major interest. He wrote evangelistic letters to many prominent people about duodecimals. He developed a set of symbols, and a nomenclature for duodecimal numbers which he termed "Consovocalic." Ultimately, he found the widest field for his energetic initiative and unusual talents in bibliographical research for the dozen system. He wrote letters, couched in English with an appended Esperanto version, to all of the larger libraries in the world, asking for lists of the catalog entries for the duodecimal works in their collections. Their gratifying responses were summarized in a series of bibliographical reports and, later, in a comprehensive Bibliography of Duodecimals, published as Volume 8, Number 2 of the Duodecimal Bulletin, October 1952. He became a member of the Society's Board of Directors.

His diabetes became troublesome, and he was subjected to a rigid insulin regime. Nevertheless, he attended all of the meetings of our Board which his physical condition permitted, because these associations were the greatest satisfaction of his life. When traveling to one of the recent sessions of the Board, in New York, he left his insulin apparatus at home, and was accorded emergency aid by Bellevue Hospital.

His will, after providing for settlement of his obligations, bequeathed the residue of his modest estate to the Duodecimal Society of America, Inc. His extensive library he gave to Ralph H. Beard toward the ultimate establishment of the library of the Society.

Lewis Carl Seelbach will continue to live in the affection and memory of those who knew him. His name is added to the Long Roll of those who bare witness to the Dozen, and continue their work beyond the limits of time and space. We ask them, our Pioneers, to welcome him, and to guide and aid us.

THE LONG ROLL

Simon di Burgos Thomas Hariot Pierre de Fermat
Blaise Pascal Gottfried Wilhelm von Leibniz
Joshua Jordaine Charles XII Johann Wiedler Edward Hatton
Christopher Vellnagel Ioannem Berckenkamp
George Louis Leclerc Etienne Bezout Joseph Louis Lagrange
Pierre Simon Laplace John Playfair
Johann Friederich Christian Werneberg Jean Etienne Montucla
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H. G. G. Robertson George Bernard Shaw Wendell B. Campbell
Warren H. Chapin Arthur Coldewe
William Addison Dwiggins Lewis Carl Seelbach

DUODECIMAL OPERATIONS FROM OLD ARITHMETICS

It is interesting to leaf through old arithmetics to discover whether they contain anything unusual about duodecimals. Even in the days of Robert Recorde, the arithmetic books included material on cross-multiplication, that they called Duodecimal Arithmetic (which, however, used only the notation of the ten-base), for computing linear measurements, areas, and cubages in feet and inches, thirds ('''), and fourths (''''). F. Emerson Andrews copied material from an old arithmetic by Benjamin Greenleaf, printed in Boston, 1860, and then Tom Linton sent us material copied from an old arithmetic purchased in Carlile, Pa., in 1845, from which the first 45 pages were missing, so that the author and title are unknown. The methods used in both are similar, but before printing either in the Bulletin it would be better that someone undertake the search for the earliest form of this arrangement.

THE DUODECIMAL SYSTEM*

by Thomas H. Goodman

When man was in the primitive stage, he used various number systems, and had no need for counting other than his wives, cattle, and few possessions. Numbers from that time until the Middle Ages were not used for calculating, but for representation of a quantity. In those simple days of long ago, any system of enumeration would have been acceptable. Some of the better known systems were the two, three, four, ten, and twenty systems, and of course the notch marks, each of which represented one. The two, or pair, system was used by many ancient tribes, but they could barely count beyond "one", "pair", "pair and one", "pair and pair". Since representing any average quantity in this system became quite a task, it was soon dropped. The three and four systems were each of a particular tribe, the former deriving its base from the three joints to the finger, and the latter deriving its base from the religious ideal of four sacred quarters to the sky. However, these two also died out. The only ones that were left were the ten system and the twenty system, for man was always bound to have his ten fingers or twenty fingers and toes. As living came to be more complex and people wanted to record greater numbers of possessions, the Egyptians developed a heiroglyphic number system based on ten, and the Mayas are noted for their system based on twenty.

Other groups came along and used the alphabet for their number systems. Two examples of this are the Hebrews and the Greeks. However, Rome soon conquered all, spreading Roman numerals throughout her empire, and the other systems were wiped out. Inefficient as Roman numerals were, they survived until the Middle Ages, and are still traditionally used for the chapters of books, the cornerstones of buildings, etc. Meanwhile, the East had been developing its own methods, and China gave a different symbol for each number up to ten. Later the Hindurs, using measuring rods, finally developed number symbols which roughly correspond to ours today. When the Arabs began their conquests, they adopted this system and spread it throughout the regions they conquered, especially Spain. Today we still call our number symbols "Arabic numerals", forgetting the credit that was due to the Hindus. By this time the digit "0" had been invented, probably the greatest invention in mathematics, for here is where the theory of our number system today is based. Finally, of course, the Arabic numerals were accepted.

\- - - - - - -

* This is a research report prepared by a young student.

Actually though, as will be pointed out later, ten is really a poor base, and when analyzing the reason for its choice, one can realize that it was purely a physiological error, based upon the fact that primitive man counted upon his fingers, of which there happened to be ten. Had he had six fingers on each hand, the whole problem of counting efficiently would never have arisen and we would have been counting duodecimally quite naturally. All number systems work on the same pattern, namely being positional notation or using what is called place value. The X-system would have X symbols, including the zero, but the highest value symbol in that system would be X minus 1. To represent X would take 1 in another column, representing 1 X^1, followed by a zero in the original column, representing 0 units or X^0. Likewise the third column would contain the amount of X's^3, etc. Thus we see the importance of the zero or empty symbol in a column in order to provide for positional notation and replace the primitive symbol writing. The digit zero is easy to figure with, especially in multiplication and forms what is called a "round" number. However, many people are misled into believing that it is because we have ten as our base that makes this so. This is definitely not the fact, for any system can use zero and enjoy its mathematical advantages. As ten is a poor base let's see how we can go about selecting a better, nearly perfect one.

An ideal number system should contain a relatively, and yet not too small, amount of numerals. It should be capable of expressing large quantities, fractions, and decimals efficiently and with as few figures as possible. Lastly, it should be easy to work with through the relationship of its numbers both to natural phenomena and mathematical principles. The base of this system should be a common factor and also have the greatest possible number of common factors. Immediately then, we may eliminate all prime numbers. Scanning all numbers from one to one hundred (p. 46), "the lowest number that has four factors is 12; the lowest that has six factors, two times 12; the lowest that has seven factors, three times 12; the lowest that has eight factors, four times 12; the lowest that has ten factors, five times 12; all others that have the maximum of ten factors, excepting only 90, are six, seven, and eight times 12. Even the reverse is true: the lowest figure with one factor is a third of 12, and the lowest with two factors is a half of 12. "The number 12 and its multiples occur in practical computations and in the multiplication tables more than any other number series." (p. 48)

For selecting a base from this series, one judges from the amount of symbols expressing larger quantities how easily and how many factors there will be in the base. Four offers one factor, six offers two factors, twelve offers four factors, sixteen offers three factors only one of which is prime, eighteen offers four factors only two of which are prime, and twenty-four offers six factors only two of which are prime. After careful analysis, both by practical experimentation and mathematical theory, it is obvious that twelve is the best base for a number system. It has now been decided that we shall use the duodecimal system!

Counting in the Duodecimal System

The duodecimal or dozen system, as its name implies means counting by twelves. Remember now, that this works on the same theory as the ten or decimal system. However, since there are twelve symbols here (0,1,2,3,4,5,6,7,8,9,10,11) and we have to count up to 12 before switching to another column, it would be best to invent symbols for ten and eleven. The Duodecimal Society has arbitrarily picked the following, which could be altered, if necessary, later (however, I believe they are quite convenient): for ten, the symbol Χ shall be used and is called "dek", stemming from the Roman numerals and language; for eleven, the symbol Ɛ shall be used and is called "el", being a shortened form of Eleven. Lastly, we need the name for the base of this system, a prime unit, which is 12. In the duodecimal system 12 is written as 10. So as to avoid its confusion as being ten in appearance (one ten and zero units), when it is really twelve (one twelve and zero units), we shall call it "do" (pronounced like "dough"), which gives it the sound of and means a "dozen". From this time onward, unless otherwise specified, all numbers in this paper shall be duodecimal numbers and all numbers in parentheses shall be decimal numbers!

We shall now count in this new system:

1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*Χ*	*Ɛ*	*10*
one	two	three	four	five	six	seven	eight	nine	dek	el	do ;
11	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*1Χ*	*1Ɛ*	*20*
do-one	do-two	do-three	do-four	do-five	do-six	do-seven	do-eight	do-nine	do-dek	do-el	twodo .

We go on through, counting this way through the twodos, threedos, fourdos, fivedos, sixdos, sevendos, eightdos, ninedos, dekdos and eldos, until we come to the very last possible number for two columns: eldo-el (eleven dozens and eleven, corresponding to our

143). Then the next number starts a new column, the third column called "gro" for gross (a gross is a dozen dozens of something, or 144). The next column after that is the fourth column called "mo" for meg-gross or the great gross (a great gross is a dozen grosses or 1,728, as is used in wholesale business). Incidentally, the Duodecimal Society has assigned various names to the columns of the powers of twelve, of an arbitrary and yet convenient nature. The nomenclature is as follows:

1	one	1
10	do	12
100	gro	144
1000	mo	1728
10,000	do-mo	20736
100,000	gro-mo	248832
1,000,000	bi-mo	2985984
1,000,000,000	tri-mo	50845335552

and so on.

We now see that this system, like our present system, works on the powers of the columns idea. Below is a comparison of the two systems:

DECIMAL

$(10)^4$	$(10)^3$	$(10)^2$	$(10)^1$	$(10)^0$
ten-thousands	thousands	hundreds	tens	units
(10,000)	(1,000)	(100)	(10)	(1)

DUODECIMAL

$(12)^4$	$(12)^3$	$(12)^2$	$(12)^1$	$(12)^0$
10^4	10^3	10^2	10^1	10^0
do-mos	mos	gros	dos	units
(20,736)	(1,728)	(144)	(12)	(1)

The only thing that will seem strange or difficult is at first the meaning or recognization of these numbers. Remember, the powers of each column of twelve (not ten) determining the value of the number is the key to the whole system! *16* means not one ten and six units, but one twelve and six units. *75* means not seven tens and five units, but seven twelves and five units. *106* means not one hundred and six units, but one gross (dozen dozens) and six units. *210* means not two hundreds and one ten and zero units, but two gross (dozen dozens) and one twelve and zero units. Below, is the whole number system up to "gro":

1	2	3	4	5	6	7	8	9	X	Ɛ	10
11	12	13	14	15	16	17	18	19	1X	1Ɛ	20
21	22	23	24	25	26	27	28	29	2X	2Ɛ	30
31	32	33	34	35	36	37	38	39	3X	3Ɛ	40
41	42	43	44	45	46	47	48	49	4X	4Ɛ	50
51	52	53	54	55	56	57	58	59	5X	5Ɛ	60
61	62	63	64	65	66	67	68	69	6X	6Ɛ	70
71	72	73	74	75	76	77	78	79	7X	7Ɛ	80
81	82	83	84	85	86	87	88	89	8X	8Ɛ	90
91	92	93	94	95	96	97	98	99	9X	9Ɛ	X0
X1	X2	X3	X4	X5	X6	X7	X8	X9	XX	XƐ	Ɛ0
Ɛ1	Ɛ2	Ɛ3	Ɛ4	Ɛ5	Ɛ6	Ɛ7	Ɛ8	Ɛ9	ƐX	ƐƐ	100

There is one other essential part of the number system, without which, it would be incomplete: decimals. This word can be interpreted two ways. Sometimes it means expressing fractional quantities as whole numbers following a point, and other times it may refer to the entire system of counting by tens. Unfortunately, some people think that fractions can be expressed as decimals only in the decimal system, which is definitely false! In fact, most common fractions are expressed better in duodecimal fractionals (one correspondent is said to have suggested "dozemals") than regular decimals!

Reading and interpreting duodecimals is essentially the same as for counting whole numbers. Remember, *.1* is one twelfth, *.01* is one one-hundred-forty-fourth, *.001* is one one-thousand-seven-hundred-twenty-eighth, etc. Also, *.10* is one twelfth and zero one-hundred-forty-fourths or twelve one-hundred-forty-fourths, *.14* is one twelfth and four one-hundred-forty-fourths or sixteen one-hundred-forty-fourths, etc.

Also, the Duodecimal Society has names for the various fractional places, based on the powers of twelve. The nomenclature is as follows:

.1	edo	1/12
.01	egro	1/144
.001	emo	1/1,728
.0001	edo-mo	1/20,736
.00001	egro-mo	1/248,832
.000001	ebi-mo	1/2,985,984
.000000001	etri-mo	1/50,845,335,552

and so on.

Again we see that the duodecimal system is similar to our system in theory of operation, yet far superior. Below is a comparison of the two systems:

DECIMAL

$(10)^1$	$(10)^2$	$(10)^3$	$(10)^4$
tenths	hundredths	thousandths	ten-thousandths
(1/10)	(1/100)	(1/1,000)	(1/10,000)

DUODECIMAL

$(12)^1$	$(12)^2$	$(12)^3$	$(12)^4$
10^1	10^2	10^3	10^4
edos	egros	emos	edo-mos
(1/12)	(1/144)	(1/1,728)	(1/20,736)

The following is a table of decimals and duodecimals for common fractions, showing an important advantage of duodecimal fractionals:

Base (12)	Base (10)	Base (12)
1/1	1.0	*1.0*
1/2	.5	*.6*
1/3	.3333333333 - - -	*.4*
1/4	.25	*.3*
1/5	.2	*.249724972497 . . .*
1/6	.1666666666 - - -	*.2*
1/7	.142857142857.....	*.186X35186X35.....*
1/8	.125	*.16*
1/9	.11111111111 - - -	*.14*
1/X	.1	*.124972497249 . . .*
1/Ɛ	.09090909090 - - -	*.11111111111 - - -*
1/10	.0833333333333 - - -	*.1*

Let us now see the reason for this advantage. In any number system, when converting to fractionals, a fraction can be expressed as whole numbers only if all its denominator's factors are factors of that system. Otherwise, the fraction resolves itself into an endlessly repeating fractional. Because twelve has a much greater variety of factors than ten, the duodecimal system is not only more efficient in expressing the frequently used common or small fractions, but can also express more fractions with complete accuracy than our present system.

There are also other advantages of expressing fractionals in the duodecimal system. Carried out to the same number of places, a duodecimal has a much greater probability of accuracy than the corresponding decimal. This superiority progressively increases with the length of the decimal. The reason for this will be obvious. A one-place decimal expresses a fractional quantity to the nearest tenth; but a one-place duodecimal expresses it to the somewhat finer division of the nearest twelfth. Similarly, a four-place decimal expresses a fractional quantity to the nearest ten-thousandth; but a four-place duodecimal expresses it to the vastly finer division of one twenty-thousand-seven-hundred-thirty-sixth. The possible error of a fractional carried to four places in the duodecimal system is only one half as great as in the decimal system. The possible error of a fractional carried to six places in the duodecimal system is only one third as great as in the decimal system.

This advantage of greater accuracy is especially beneficial in such as logarithms and constants of the circle. A simple and yet striking example of the superiority of the duodecimal is in the following demonstration. The square root of 2, most of us learned at one time or another, is 1.4142. Duodecimally, it is *1.4Ɛ79*, or very close indeed to *1.5*. Consider how close *1.5* is, by definition, 1 and 5/12, or 17/12. Square this fraction by ordinary mathematical methods, and we arrive at 289/144, or 2 and 1/144. Obviously, *1.5* is a very close value for $\sqrt{2}$. It is in fact closer than even the nearest two-place decimal, and in many computations the very simple expression, *1.5*, may be used for the square root of 2.

Another advantage is percentage, which, being similar to decimals, is far superior in the duodecimal system for the same reasons. Also, a two-place duodecimal expresses approximately two-thirds of all fractions more accurately than a two-place decimal. It is just as easy to arrive at percentage in the twelve system as in the ten system. One simply divides the numerator by the denominator, and carries out to two places. But for most practical purposes, duodecimal percantage is vastly simpler to work with than our present system. Here, one third is 40% and two-thirds is 80%; one quarter is 30% and three-quarters is 90%; one sixth is 20%; one eighth is 16%; one ninth is 14%; one twelfth is 10%; and one sixteenth is 9%. Lastly, were there to be a similar twelve-division of the dollar instead of our present ten, again, because of the great factorability of twelve, there would be a shorter and more efficient way of expressing prices, and much time saved in calculating. Thus we see the reasons for superiority in duodecimals.

(Please turn to Page 4X.)

ONE LANGUAGE FOR THE WORLD

The devil's most useful tool in fomenting misunderstanding among mankind is the difference in languages. Our people recognize this well, for we are one of the most loose-footed of folks, - seeking friendly communication with all the world. But, oft-times, a smattering of acquaintance with another's language can lead to graver misunderstanding than would out-right ignorance.

It is fairly well agreed that we should have an international language which every educated person would learn in addition to his native tongue. Thus everyone would have at least one channel of communication with everyone else. The question is: "Which one?"

Naturally, we think that if everyone were to learn English in addition to his national language, the problem would be solved. But those who do not speak English find it the most difficult language to learn. And English rates poorly in the most essential requirement: an international language must be completely phonetic. It is also well argued that no natural language can serve well for international use because the international language must be entirely regular in its structure, and must remain so.

Courses in the more general of the world's languages are available in our schools, and two or three years study of several languages is a common requirement. But lack of use soon evaporates such superficial acquaintance. Dr. James B. Conant recommends, instead, that we should concentrate on learning one other language thoroughly.

Mario Pei, in his recent splendid work, "One Language for the World," offers a startlingly simple and practical solution for this problem. His point is that any one of the leading natural or artificial languages could serve about equally well. He offers a plan which could yield the selection of an international language within two years, and could, within seven years, start the progression of training in that language upwards through the grades of our schools. His proposal merits the utmost in publicity and public discussion.

see also World Languages by Mario Pei — Book?

Dr. Pei suggests that we propose the formation, by UNESCO, of a Linguistic Commission, with proportional representation of all nations, to select the international language, - with the undertaking that the nations would accept the selection of the Linguistic Commission, and would provide for teaching that language in their schools.

After a year of study and preparation, the delegates of the Linguistic Commission would convene, and proceed to nominate their choices for the international tongue. The nominations would then be closed, and the delegates would proceed to vote for their choice. At each balloting, that half of the languages which received the fewest votes would be eliminated. In about eight ballotings, the choice will have been accomplished.

Dr. Pei suggests than an interval of about five years follow the selection, - for any necessary modification of the chosen language for international use, - and for the training of teachers. Then, starting from the lowest grades, and progressing as rapidly as possible, the international language would become part of the basic curriculum, beside the native language.

By then, the world would be well on its way toward dissolving the language barrier. And communication between all peoples would be eased. The simplicity of this proposal makes it common sense to choose this way to select the common international language.

THE DUODECIMAL SYSTEM

(Continued from Page 48)

Advantages and Disadvantages

Now that we've had a good view of what the duodecimal system is about and how it works, let's consider its advantages and possible disadvantages. The main advantage is that twelve has a greater number of factors than ten. It has always been more important to be able to divide things into a greater variety of parts than to multiply them. The duodecimal system is easier to work with through the excellent relation of twelve to natural phenomena and mathematical principles. 2, 3, and 4 especially are important, only the first of which is contained as a factor in our system. In fact, the 5 in our system is very irregular and poorly suited to everyday needs. It has been forced into effect because of our awkward number system. The decimal system thus is literally "unsatisfactory"! The common or practical man still prefers division by 2, 3, or 4. Imagine for a few minutes the sorry situation if there were 5 cardinal directions; 35 inches to the yard, being divisible only by fifths, sevenths, and thirty-fifths; or the day were divided into 25 hours, making all computing with fractions of a day frustrating. All, of course, would be logical under our present system.

On the other hand, consider the advantages we enjoy today with our natural units of measurement. Most articles in a store are sold by the dozen or gross, which by the way is where our word "grocer" comes from, meaning one who deals by the gross. There are twelve months to the year, twelve hours on our clocks, sixty (5 x 12, since that is the lowest number on which 10 and 12 could meet) minutes to the hour, and sixty seconds to the minute, twelve inches to the foot, thirty-six inches to the yard, three hundred sixty degrees to the circle, and too many more to name here. All of our present ways of measuring weight, capacity, space, distance, time, latitude and longitude (360°), etc. are based on geometrical and physical laws which the ten system does not and can not meet. The question seems to be: Shall we make our natural measure system conform to our poor and arbitrarily picked number system of ten, by accepting the metric system, or rather change our number system to the natural duodecimal system to match with our natural measure system? All have recognized the clash between the two systems. Unfortunately man seldom questions the habitual, and few recognize the advantages of the duodecimal system. Because people are resentful to change, they continue to use both systems, complicating millions of calculations daily.

Actually, upon analyzing the situation, there is only one chief disadvantage to the duodecimal system, and only an immediate one at that! This should be obvious: We are accustomed to a different number system. It might take people some time to get used to this new system, at least six months. People would have to remember to count to a dozen before counting or calculating, and learn to read the new numbers correctly. There would also be a few side effects. The main one would be altering dates in books, etc., and learning to deal with obsolete numbers in the decimal form. We would probably do this by putting decimal numbers in parentheses, just as is done in this paper. However, this would be only relatively immediate, and in a matter of years ought to be forgotten.

Certainly I doubt if this system will be accepted soon. But, just as man in the middle ages realized the inadequacy of Roman numerals, and gave them up despite the fact that he wanted immediate results, so I think that one day we may give up our decimal system for a better one based on twelve!

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Schumacher, William C.
Letter to the Editor,
Military Automation, Mar.-Apr. 1957, p. 66/7.

Commenting on article on Modern Digital Techniques in previous issue, emphasizes omission of the duodecimal in its review of number bases, and mentions its advantages.

More 12 Place Math.
Product Engineering, Vol. 43, No. 9, Sept. 1952, p. 274.

Hearty endorsement of Whiteside's advocacy of duodecimals, and unusually able presentation of the more technical advantages of duodecimals.

Scientific American
Duodecimal System,
R. C. Eldridge, Vol. 88, May 1903, p. 335.

A duodecimal rejoinder to a pro-metric letter by Hubbard.

Duodecimal System,
N. Y. Hubbard, Vol. 88, Apr. 1903, p. 299.

Letter against the duodecimal proposal of Sidney A. Reeves before the A. S. M. E. Strongly pro-metric.

Scripta Mathematica
Natural Numbers as Cardinals,
Fraenkel, Abraham Adolf

Essay on the consideration of number systems as a special case in the theory of sets. Cites 10-base as inferior to 6 or 12.

Surveying and Mapping
Nomenclature for Base Twelve Numbers,
Paul Van Buskirk, Vol. 12, No. 3, July-Sept. 1952, p. 248.

An able presentation of the duodecimal proposals, advocating the author's system of names for duodecimal numbers, based on the Roman nomenclature.

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Arithmetic for Teacher Training Classes.

Reference to Andrews' New Numbers, at end of Chapter 1.

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Vincent, L. H.
Duodecimal System of Notation,
School Science and Mathematics, Vol. 9, No. 10, Oct. 1909 p. 555-562.

Excellent article on the 12-base. Uses x and y for dek and el.

Wahlert, Howard E. see *Hollis R. Cooley.* Joint author.

Wells, Henry George
Many favorable references to duodecimals.

see	Anticipations	1901
	A Modern Utopia	1905
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Whiteside, John E.
Complaint against the Decimal System,
Product Engineering, Vol. 43, No. 6, June 1952, p. 264.

Letter to the Editor, voicing strong criticism of the decimal system, and advocating the duodecimal. Supplemented by an excellent exposition of the duodecimal system by Editor Nordenholt, "We're interested in hearing what our readers think of this system for counting and measuring."

Wickham, J. J.
A Suggestion for Duodecimals,
The Mathematics Teacher, Vol. 46, No. 2, p. 110.

Suggests the use of ⊗ for 𝒳, and Ø for Ɛ.

Williams, Rufus P.
Ancient Duodecimal System
School Science and Mathematics, Vol. 9, No. 9, Sept. 1909, p. 516/21.

An excellent paper on the weights and measures of antiquity, favoring a duodecimal system and a duodecimal notation.

BARRIERS AWAY!

Tonko Tonkov, of Sofia, Bulgaria, is a good friend of our Society and a fervent Esperantist. He writes us (in Esperanto), that in the Russian journal, Referative Mathematical Review, No. 6, 1957, there appeared the following item:

No. 4594. A Duodecimal Notation with Commercial and Scientific Tables, Hallwright, Horatio W. Duodecimal Bulletin, Vol. 10, No. 1, 1 - 6, (angla).

Propagandizes for the duodecimal calculation. Tables are given of the author's proposal of a system of measures of length, area, volume, weight, money, time - in duodecimal numeration.

(translation uncertain) noted by: B. A. Torydeb, Golubev, V. A. 1.