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Adobe Portable Document Format Version of

Four "Extraterrestrial" Articles from the NSA Technical Journal

07-November-2006

This PDF file contains the released text of four articles that were printed in the internal National Security Agency (NSA) publication, the NSA Technical Journal. Each of these articles has the term "extraterrestrial" or similar term in the title. While these articles are not directly related to any research on extraterrestrial existence or the like, they do show that the idea wasn't completely foreign to NSA Staff. The articles are:

1. Book Review: Lincos, Design of a Language for Cosmic Intercourse, Part 1, Vol. VII, No.1, Winter 1952, NSA Technical Journal.
2. Communications with Extraterrestrial Intelligence, by Lambros D. Callimahos., Vol. XI, No. 1, Winter 1966, NSA Technical Journal.
3. Communications with Extraterrestrial Intelligence, by Howard H, Campaigne, Vol. XI, No. 2, Spring 1966, NSA Technical Journal.
4. Key to the Extraterrestrial Messages, by Howard H Campaigne, Vol. XIV, No. 1, Winter 1969, NSA Technical Journal.

This material is presented here is to make it publicly available and to eliminate speculation and controversy over the contents of these articles with such provocative titles.

Thanks goes to Researcher Michael Ravnitzky for obtaining previously unreleased bibliographies and indices of NSA publication which may be viewed here: http://www.thememoryhole.com/nsa/bibs.htm

Please note one item listed in the NSA release letter is not reproduced here. It relates to a different subject; Pearl Harbor.

- Jim Klotz - CUFON SYSOP
- Dale Goudie - Information Director

NATIONAL SECURITY AGENCY
CENTRAL SECURITY SERVICE
FORT GEORGE G. MEADE, MARYLAND 20755-6000

FOIA Case: 51289
5 October 2006

Mr. James Klotz

Dear Mr. Klotz:

This responds to your Freedom of Information Act (FOIA) request of 29 August 2006, which was received by this office on 1 September 2006, for "copies of the following articles for the below cited issues of the NSA Technical Journal:

1. Book Review: Lincos, Design of a Language for Cosmic Intercourse, Part 1, Vol. VII, No.1, Winter 1962, NSA Technical Journal.
2. Communications with Extraterrestrial Intelligence, by Lambros D. Callimahos, Vol. XI, No. 1, Winter 1966, NSA Technical Journal.
3. Communications with Extraterrestrial Intelligence, by Howard H. Campaigne, Vol. XI, No. 2, Spring 1966, NSA Technical Journal.
4. Key to the Extraterrestrial Messages, by Howard H. Campaigne, Vol. XIV, No. 1, Winter 1966, NSA Technical Journal.
5. Book Reviews: Pearl Harbor: Warning and Decision, Roberta Wohlstetter, Vol. VIII, No. 1, Winter 1963, NSA Technical Journal."

Your request has been assigned Case Number 51289. For purposes of this request and based on the information you provided in your letter, you are considered an "all other" requester. As such, you are allowed 2 hours of search and the duplication of 100 pages at no cost. There are no assessable fees for this request.

Your request has been processed under the provisions of the FOIA. Enclosed is the material you requested.

Sincerely,

for Marianne Stupar

PAMELA N. PHILLIPS
Chief
FOIA/PA Office

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NSA TECHNICAL JOURNAL

VOL. VII WINTER 1962 NO. 1

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Book Review

Lincos, Design of a Language for Cosmic Intercourse, Part I: Hans Freudenthal; 224 pages; $6.25; North-Holland Publishing Company, 1960. Reviewed by Joseph Blum. (Unclassified)

The exploration of outer space has begun and it is expected that serious scholars will begin to consider various problems associated with cosmic communications. In this book the author sets for himself the task of designing a language for cosmic communication. Professor Freudenthal, a professor of mathematics at the University of Utrecht (and recently a visiting professor at Yale), brings to this task the capabilities of the mathematician, teacher and linguist. The language developed by Freudenthal is called Lincos (his acronym for "lingua cosmica").

Considering the difficulties in the way of establishing physical communication with our nearest cosmic neighbors, we must agree that such communication is remote from now. However, if such communication is ever to become a reality we must begin to solve some of the problems that the author recognizes and attacks. The author is primarily concerned with the development of formal language for the purpose of communication. As a first goal he chooses "to design a language that can be understood by a person not . . . acquainted with any of our natural languages or even their syntactic structures." How well the author has succeeded is subject to debate. There are no means available to objectively evaluate the language under the stated terms of reference. In fact, the terms of reference are not well defined. The author assumes "that the person who is to receive my messages is human or at least humanlike as to his mental state or experiences . . . Yet I shall not suppose that the receivers of my messages must be humans or humanlike in the sense of anatomy or physiology."

What makes the problem even more intriguing is that Lincos must be taught to the receiver under challenging circumstances, i.e., with no previously established means of communication and with messages sent in only one direction from teacher to student. Under these constraints, the first few lessons in Lincos are crucial, for if they are not understood everything which follows will be incomprehensible. To meet this difficulty, the author proposes to begin by communicating facts which can most assuredly be supposed to be known to the receiver and by using the simplest and most reliable didactic principles. Mathematics is selected as the subject with which to begin the teaching program for it "may be supposed to be universally known to humanlike intelligent beings."

The definite program to be broadcast will consist of a large number of pieces called program texts. The material presented in the book is considered to be an abstract from the definite program. The program texts have been collected in paragraphs and chapters. The chapter titles are I Mathematics, II Time, III Behaviour, IV Space, Motion, Mass. Further chapters on "Matter", "Earth", "Life" and "Behaviour" are planned by the author in a second volume on Lincos.

There are two versions of Lincos—(1) spoken Lincos, which is broadcast and in which the information is quantized into phonemes and (2) written Lincos, a conveniently coded form suitable for printed exposition such as the author's book. Lincos notation borrows heavily from mathematics and the Lincos words are abbreviations or contractions from the Latin equivalents. Thus the Lincos word *Num* means "natural number" (from the Latin *numerus*). Punctuation is the principal means of showing Lincos syntactic structure. The Russell-Whitehead system of dots is adapted for use as containment symbols although the conventional usage of parentheses might have been a better choice for the readability of Lincos.

Chapter I sets out first to introduce the natural numbers, the order relations and the operations of addition and subtraction. The abstract from the factual program is as follows (# used for "begin" and "end" marks):

1. # · · · · · > · · · # etc
2. # · · · <· · · · · # etc
3. # · · · · = · · · · # etc
4. # · · · · + · · = · · · · · · # etc
5. # · · · · · · – · · = · · · · # etc

In this text the Lincos phoneme corresponding to the round dot is a short radio-signal (a peep). A Lincos word consisting of n successive phonemes of this kind both means and shows the natural number n. In the next lesson these numbers are superseded by numbers in binary notation. The program text begins with

· = 1
· · = 10
· · · = 11
· · · · = 100
· · · · · = 101 #
etc.

From this point on all numbers are represented in binary notation. The author proceeds to introduce the concept of a variable and to

develop the concepts of the logical connectives. The fundamental facts for the number systems are presented—first for the integers, then for the rational numbers, the real numbers and finally the complex numbers. By the end of the chapter there is enough apparatus to deal with the formal definition of group and field using the familiar axioms of modern algebra. The chapter terminates with a presentation of the basic facts of the propositional calculus. The Lincos vocabulary at this point includes such words as "true", "false", "proposition", "question", and "truth-value". It is highly plausible that the Lincos language of Chapter I could be learned by a human-like person acquainted with our kind of mathematics.

Chapter II is designed to teach all the basic temporal concepts and relations. As in mathematics, the start is made with the use of ideophonetic signs. Time signals of various duration and wavelength are shown together with numbers and symbols. In this way the unit of time is introduced. Duration, frequency and the number of oscillations are introduced. Words are introduced meaning "begin", "end", "before", "after", "precedes", etc. Finally a time-clock is installed to serve as a frame of reference for all further communications about events. The linguistic devices which are used to name and describe events can be expected to be harder for the cosmic pupil to penetrate. Perhaps the author expects the subsequent program texts in later chapters to provide help in exposing the semantics of this area of Lincos.

Chapter III, on human behaviour is the longest, most difficult and most interesting chapter in the book. To cope with this complex topic, Lincos must be augmented with the essential elements of vocabulary and grammar which are common to most natural languages. Behaviour is displayed by presenting short one-act plays. The first of these are very simple and consist of dialogues. The author begins by showing good and bad behaviour and introducing words which mean "good" and "bad". At the outset these words simply indicate approval or disapproval. As an example of the technique, consider the following texts presented in a free English translation of Lincos:

A speaks B : ?x (2x = 5)
B speaks A : 5/2
A speaks B : good
· · · · · ·

A speaks B : ?x (4x = 10)
B speaks A : 10/4
A speaks B : bad
B speaks A : 1/2
A speaks B : bad

B speaks A : 5/2
A speaks B : good
. . . . .
A speaks B : ?x ($x^2 = 25$)
B speaks A : $5 \times 5 = 25$
A speaks B : bad
B speaks A : ($5 \times 5 = 25$) is true
A speaks B : true but bad; not ($x^2 = 25 \rightarrow x = 5$)
B speaks A : 5 or -5
A speaks B : good

Another clue which helps to distinguish "good" from "bad" is contained in the text:

A speaks B : ?x ($4x = 10$)
C speaks A : 5/2
A speaks C : bad
B speaks A : 5/2
A speaks B : good
. . . . .

From these very modest beginnings the author rapidly develops enough language to display rather complicated behaviour. Here are some examples:

1. An individual recites a short history of Fermat's theorem on the existence of solutions to the equation $a^n + b^n = c^n$.

2. An actor agrees to give information about a certain event on condition that the other will keep the information secret. When asked about this event, the other refuses to give the information because he has promised secrecy.

3. A bet is made on solving a cubic equation. The winner refuses to tell the general method of solution. The loser refuses to pay. An arbiter is called in. The winner then tells his method and the loser pays up.

There is little doubt that the lessons contained in Chapter III constitute, for the learner, the major hurdle in mastering the Lincos language. With the support of some generous foundation, experimentation with people might develop enough evidence to determine the plausibility of success. Quite apart from settling this question, such research might yield results which could be applied to the learning of foreign languages and to the design of more powerful problem-oriented programming languages.

In Chapter IV the author introduces the basic physical concepts such as length, mass, velocity, acceleration, density, etc. Mechanical

concepts are introduced by acts of behaviour and later embedded into a mathematical system. The physicists will be interested in the author's discussion of the various ways to introduce the concept of length. He decides to do this indirectly by indicating the numerical value for the velocity of light. This information together with the knowledge of the time unit then makes it possible for the receiver to deduce the unit of length. The author furnishes opportunities to confirm correct conjectures by supplying physical and astronomical data such as Rydberg's constant for hydrogen, the universal gravitation constant, the mass of the hydrogen atom, distances between astronomical bodies, etc. The texts discuss such things as elastic collision of bodies, the law of universal gravitation and the solar system. The chapter concludes with a brief discussion of relativistic mechanics and a derivation of the well-known mass increase formula.

To assist the reader, the author has provided a summary of the program texts and a register of the symbols and vocabulary of Lincos. The printing of the text maintains the high quality and standards which have been exhibited in the publisher's series entitled Studies in Logic and the Foundations of Mathematics. The reviewer warmly recommends this book to all who enjoy a delicious potpourri of mathematics, logic and linguistics.

—J. B.

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Communication with Extraterrestrial Intelligence[1]

BY LAMBROS D. CALLIMAHOS

Unclassified

We are not alone in the universe. A few years ago, this notion seemed farfetched; today, the existence of extraterrestrial intelligence is taken for granted by most scientists. Sir Bernard Lovell, one of the world's leading radio astronomers, has calculated that, even allowing for a margin of error of 5000%, there must be in our own galaxy about 100 million stars which have planets of the right chemistry, dimensions, and temperature to support organic evolution. If we consider that our own galaxy, the Milky Way, is but one of at least a billion other galaxies similar to ours in the observable universe, the number of stars that could support some form of life is, to reach for a word, astronomical. As to advanced (by miserable earth standards) forms of life, Dr. Frank D. Drake of the National Radio Astronomy Observatory at Green Bank, West Virginia, has stated that, putting all our knowledge together, the number of civilizations which could have arisen by now is about one billion. The next question is, "Where *is* everybody?"

The nearest neighbor to our solar system is Alpha Centauri, only 4.3 light years away; but, according to Dr. Su-Shu Huang of the National Aeronautics and Space Administration, its planetary system is probably too young for the emergence of life. Two other heavenly friends, Epsilon Eridani and Tau Ceti, about 11 light years away, are stronger contenders for harboring life. Nevertheless, if superior civilizations are abundant, the nearest would probably be at least 100 light years away; therefore, it would take 200 years for a reply to be forthcoming, a small matter of seven generations. This should, however, make little difference to us, in view of the enormous potential gain from our contact with a superior civilization. Unless we're terribly conceited (a very unscientific demeanor), we must assume that the "others" are far more advanced than we are. Even a 50-year gap would be tremendous; a 500-year gap staggers the imagination, and as

[1] The substance of this article was presented at a panel discussion of the same title during the 1965 IEEE Conference on Military Electronics held in Washington, D. C., on 23 September 1965. Besides the author as cryptologist, the other members of the panel were Dr. Paul Garvin, linguist; Dr. John C. Lilly, delphinologist; Dr. William O. Davis, physicist; and Fr. Francis J. Heyden, S. J., astronomer. The moderator was Dr. Harold Wooster, Director of Information Services of the Air Force Office of Scientific Research.

for a 5000-year gap . . . (By the way, if they are as much as 50 years *behind* us, forget it!) It is quite possible that "others" have satellite probes in space, retransmitting to "them" anything that sounds nonrandom to the probe. But they have probably called us several thousand years ago, and are waiting for an answer; or worse yet, they have given up; or, more probably, they have reached such impressive technological advances that they have destroyed themselves.[2]

Epsilon Eridani and Tau Ceti were the targets on which Dr. Drake focussed his attention in the spring of 1960 in Project Ozma, an attempt to detect possible intelligent signals from outer space. The frequency selected for listening was 1420.405752 megacycles per second, or a wave length of 21 cm. This particular frequency, postulated independently by two professors on the faculty of Cornell University, Giuseppe Cocconi and Philip Morrison, happens to be the radiation frequency of atomic or free hydrogen which permeates space in great clouds; moreover, this frequency is within the range of radio frequencies able to pass through the earth's atmosphere. Presumably, the significance of this frequency would be known to other intelligent beings in the universe who understand radio theory. We're still talking about radio waves as the communication medium; other possible media might be masers, lasers, or the as yet undiscovered and unnamed "rasers." A technology superior to ours might even have learned how to modulate a beam of neutrinos (weightless, uncharged particles that physicists on earth find it difficult even to detect); if so, "they" may have to wait a century or two before we learn how to build a neutrino receiver.

If another civilization were trying to establish communication with us, it would first embark on attention-getting signals of such a nature that we could distinguish them from random cosmic noise; once we receive a recognizable signal, we have a good chance of understanding the message. For example, they could start with trains of signals corresponding to the natural numbers 1, 2, 3, . . . , followed perhaps by prime numbers. They might continue with equal-length extended signals consisting of start and stop impulses, with occasional pulses in

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[2] In this connection, Professor Iosif Shklovsky, Russia's greatest radio astronomer, has the following to say in the September 1965 issue of *Soviet Life:*

"Profound crises lie in wait for a developing civilization and one of them may well prove fatal. We are already familiar with several such critical [situations]:

(a) Self-destruction as a result of a thermonuclear catastrophe or some other discovery which may have unpredictable and uncontrollable consequences.

(b) Genetic danger.

(c) Overproduction of information.

(d) Restricted capacity of the individual's brain which can lead to excessive specialization, with consequent dangers of degeneration.

(e) A crisis precipitated by the creation of artificial intelligent beings."

between; when these signals are aligned flush over one another, they would show a circle, the Pythagorean Theorem, or similar geometric design. These attention-getting signals would be followed by early "language lessons," interspersed with items of technical information to help bring us up to the level of our superiors, "them."

It may be assumed that the sense of sight, or an equivalent, is possessed by all higher forms of life; the problems of communication could thus be greatly simplified through the medium of a "raster" representation such as that of a television screen. After a conference held at Green Bank in 1961 to discuss the possibility of communication with other planets, one of the participants, Bernard M. Oliver, made up a hypothetical message on the raster principle. The message, consisting of 1271 binary digits or "bits," is shown in Fig. 1. Since 1271 has but two prime factors, 31 and 41, we would naturally be led to write out the message in raster form, in 41 lines of 31 bits each, or in 31 lines of 41 bits each; the latter case reveals a greater nonrandomness in the patterns disclosed, indicating that these are the correct dimensions. In Fig. 2 is the write-out of the message, in which the binary 1's have been replaced by a dot and the 0's left as blank spaces. Now for its interpretation.

There are dots at the four corners of the pictogram as reference points, marking the outlines of the rectangle. At the upper left is a representation of the sun; directly underneath in a column are dots representing 8 planets, identified by the appropriate binary coding to their left, preceded by a binary point as a marker. The erect, two-legged beings illustrated are obviously bisexual and mammalian; one hand of the male figure points to the fourth planet where they apparently reside. At the top of the pictogram may be seen representations of hydrogen, carbon, and oxygen atoms, indicating that the chemical structure of life on their planet is similar to ours. From the third planet there emerges a wavy line, showing that it is covered with water; the representation of a fish shows that they must have visited us and therefore have space travel. One hand of the female figure points to a six (preceded by the usual binary point), perhaps implying that there are six fingers on each hand; we could therefore assume that their number system is probably to the base 12. At the right of the female figure may be seen a bracket, in the middle of which is eleven in binary form (preceded by a binary point): this implies that the beings are 11 units high. A reasonable interpretation is that the unit is 21 cm., the wave length of the transmission, making them about 7½ feet tall, which should be all right for average Martians.

In 1952 the British mathematician Lancelot Hogben delivered an address before the British Interplanetary Society entitled "Astraglossa, or First Steps in Celestial Syntax." Hogben pointed out that *number*

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1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0
0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0
0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0
0 1 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1
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1 1 0 1 1 0 1 1 0 1 0 0 1 1 0 0 0 0 1 1 0 0 1 0 1 1 0 0 1 0 1 1 0 0 1 0 0 1 0 0
1 0 0 1 0 0 1 0 0 1 0 1 0 1 0 0 1 0 0 1 0 0 0 0 1 1 0 0 0 0 1 1 0 0 0 0 1 1 0 0
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0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0
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0 0 0 1 0 0 0 0 1 1 1 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0
0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 1 0 0 0 1 1 0 0 0 0 1
0 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 0 0 1 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 1
1 0 0 0 0 0 1 1 0 1 1 0 0 0 1 1 0 1 1 0 0 0 0 0 1 1 0 0 1 1 1
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Fig. 1.

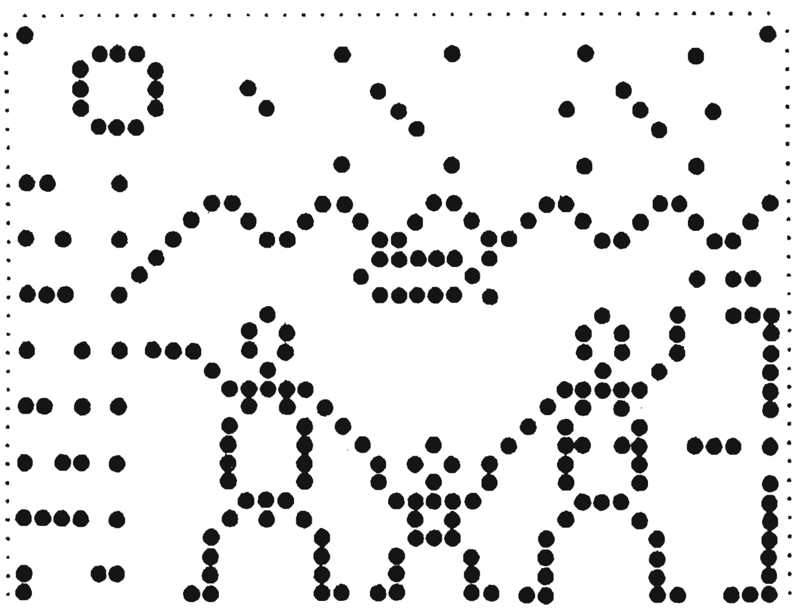

Fig. 2.

is the most universal concept for establishing communication between intelligent beings; therefore, mathematics forms the basis for the first steps in extraterrestrial communication. He then illustrated how he could transmit pulses representing integers, and distinctive signals or "radioglyphs" representing "+", "−", "=", and so on. Morrison later carried out the basic idea a little further, using different pulse shapes to represent elementary mathematical symbols. An entirely different approach was developed by Hans Freudenthal, Professor of Mathematics at the University of Utrecht, who in 1960 published a book entitled "Lincos: Design of a Language for Cosmic Intercourse." "Lincos," an acronym of "lingua cosmica," tries to establish a communication of ideas through symbolic logic, but the general consensus of those who have taken the trouble to study his book is that his plan is too difficult. After all, the object of the exercise is getting ideas across to another party, whose thinking processes may be entirely different from our own. In other words, what we need to develop is an "inverse cryptography," or communication symbolism specially designed, not to hide meaning, but to be as *easy* as possible to comprehend. Cleverness on the part of the *sender* is then the important factor, not reliance on ingenuity of the recipient. The inverse cryptographer—somehow, this term doesn't sound quite right—must make his meaning clear to the recipient, even if the latter does not possess a cosmic equivalent of the Rosetta Stone.[3]

As an illustration of how much information could be conveyed with a minimum of material, and as an example of facile inverse cryptography, let us consider a message I have devised to be typical of what we might expect of an initial communication from outer space. In Fig. 3 is shown a series of transmissions which could have come from another inhabited planet, many light years away. The 32 arbitrary symbols are representations for the 32 different signals (combinations of beeps, or distinctive pulse shapes) heard on a frequency of 1420.4 megacycles. The punctuation marks are not part of the message, but here represent different time lapses: adjacent symbols are sent with a short pause (1 unit) between them; a space between symbols means a longer pause (2 units); commas, semicolons, and periods indicate pauses of 4, 8, and 16 units, respectively. Between transmissions (numbered here for reference purposes) there is a time lapse of 32 units.

The first transmission, (1), is obviously an enumeration of the 32 different symbols which will be used in the communications; in transmission (2) is the clear implication that A represents the integer 1, B

[3] The Rosetta Stone is a piece of black basalt found in 1799 near the Rosetta mouth of the Nile, bearing a bilingual inscription (in Egyptian hieroglyphics, Egyptian demotic, and Greek) with which Jean François Champollion was able to solve the mystery of the Egyptian hieroglyphs.

(1) A. B. C. D. E. F. G. H. I. J. K. L. M. N. O. P. Q. R. S. T. U. V. W. X. Y. Z.
•. &. $. ¢. ≠. @. A. B. C. D. E. F. G. H. I. J. K. L. M. N. O. P. Q. R.
S. T. U. V. W. X. Y. Z. •. &. $. ¢. ≠. @.

(2) A A, B; A A A, C; A A A A, D; A A A A A, E; A A A A A A, F; A A A A A A A, G;
A A A A A A A A, H; A A A A A A A A A, I; A A A A A A A A A A, J.

(3) A K A L B; A K A K A L C; A K A K A K A L D. A K A L B; B K A L C; C K A L D.
B K C L E; E L B K C; F K D L J; J L D K F. E L K E; K E L E.

(4) C M A L B; D M A L C; G M E L B; E M G L M B.

(5) D K N L D; G K N L G; F M F L N; E M E L N.

(6) J L AN; J K A L AA; J K B L AB; AA K A L AB. J K J L BN; J K J K J L CN;
IN K C L IC.

(7) B O C L F; D O B L H; E O B L AN; D O AN L DN.

(8) F P C L B; H P B L D; J P B L E; J P E L B.

(9) A P J L Q J; A P ANN L Q ANN; Q J, P J L Q ANN.

(10) Q J L R A; Q J O B L R B; A R E M A L R E L E O Q J. Q ANN L R NA;
Q ANN O B L R NB.

(11) H L H; G S C, C S G. D K A L C K B; D K C S E K A; E K A S D K C.

(12) D T A; D T B; D T C; D L D; D U E; D U F; D U G. J T I; J U AA.

(13) FIRII V GN; ANNN K C V ANNN; AN P C V CRC.

(14) W E K A X L E K A; B W E K A X L W B O E X K W B O A X L B O F.

(15) C Y B L I; E Y B L BE; B Y E L CB; W D K A X Y B L BE.

(16) BE Z B L E; FD Z B L H; BG Z C L C; ABE Z C L E. W AI K F X Z B L E.
BE Z B L M E; M ABE Z C L M E. BE Z B L KM E.

(17) D • L D O C O B O A L BD; E • L E O D O C O B O A L ABN; H • L DNCBN.

(18) & P D L A M Q C K Q E M Q G K Q I M. & V CRADAEI.

(19) $ L A K Q W A • X K Q W B • X K Q W C • X K Q W D • X K. $ V BRGAHBH.

(20) ¢ E K A ≠ L W E K A X; B ¢ E K A ≠ L B W E K A X;
B ¢ E K W D K C X ≠ L B W E K G X. ¢ B ≠ ¢ D ≠ L W B X W D X L B O D.

(21) $ Y ¢ & O W M A X Z B ≠ K A L N.

(22) B K C L ¢ @NNA ≠; B K C L E. C O D L ¢ @NNA ≠; C O D L AB.
D Y B L ¢ @NNA ≠; D Y B L AF.

(23) B K C L E; ¢ @NNB ≠. B K D L E; ¢ @NNC ≠. E Y B L BE; ¢ @NNB ≠. F Y B L C E;
¢ @NNC ≠. I T E; ¢ @NNB ≠. H U C; ¢ @NNC ≠. & V BRGAHBH; ¢ @NNC ≠.

(24) B L ¢ @NND ≠. C L ¢ @NND ≠. E, G, AA, AC, AG, ¢ @NND ≠. ANA ¢ @NND ≠.

(25) ¢ @NNE ≠ L B O & ¢ @A ≠; ¢ @NNF ≠ L & ¢ @A ≠ Y B. ¢ @A ≠ L ¢ @NNG ≠.
¢ @NNE ≠ L B & ¢ @NNG ≠; ¢ @NNF ≠ L & ¢ @NNG ≠ Y B.

(26) ¢ @NNH ≠ L D O Q C O & ¢ @NNG ≠ Y C.

(27) Q B K Q D K Q H K Q AF K Q CB V A;
Q B K Q D K Q H K Q AF K Q CB K ¢ @NNI ≠ L A.

(28) C K ¢ @A ≠ L G; ¢ @A ≠ L D. I K ¢ @A ≠ L AB; ¢ @A ≠ L C.
FD Z ¢ @A ≠ L H; ¢ @A ≠ L B.
¢ @A ≠ L A, R GG, M R GG, J P C, &, K, M, ¢ @NNI ≠.
¢ @B ≠ L A, R GG, M R GG, J P C, &, K, M, ¢ @NNI ≠.
¢ @C ≠ L A, R GG, M R GG, J P C, &, K, M, ¢ @NNI ≠.

(29) ¢ @NNE ≠ L B & ¢ @B ≠; ¢ @NNF ≠ L & ¢ @B ≠ Y B.
¢ @NAN ≠ L B ¢ @C ≠ K B ¢ @D ≠; ¢ @NAA ≠ L ¢ @C ≠ O ¢ @D ≠.

(30) ¢ @NNE ≠ L ¢ @NAB ≠, ¢ @NAC ≠; ¢ @NNF ≠ L ¢ @NAD ≠, ¢ @NAC ≠.
¢ @NAN ≠ L ¢ @NAB ≠, ¢ @NAE ≠; ¢ @NAA ≠ L ¢ @NAD ≠, ¢ @NAE ≠.

Fig. 3.

the integer 2, . . . , J the integer 10. In the first twenty transmissions there are introduced symbols for the introductory expository treatment in teaching us their mathematics. Among the items treated are: addition, subtraction, multiplication, and division; decimal notation and the concept of zero; inequalities and approximation; powers and roots; and definitions of π and e. Transmission (21) adds nothing new to the 31 symbols recovered thus far, but it does quote one of the most beautiful concepts in pure mathematics: they are telling us that, if they can teach us such a complex notion at this early stage, we will be staggered by what they will teach us by the 200th or the 2000th transmission. Beginning with transmission (22), words and word-cluster concepts are introduced, so that by the time we come to transmission (30), we now are understanding, in a manner of speaking, pure Venerean. Furthermore, we can now see how we could recover the code they are using on us, and which will obviously consist of thousands upon thousands of code groups with different meanings; this is easily appreciated by anyone who takes the trouble to fathom the meaning of all 30 transmissions in the foregoing example.[4]

Even right after this first message, if we are in direct communication with that planet, we shall have questions to put to "them": the proof of Fermat's Last Theorem, Goldbach's conjecture,[5] and many other unsolved problems in mathematics and the natural sciences. It will not be difficult for "them" to demonstrate their intellectual and technological superiority (first of all, don't forget it was *they* who were able to call *us*!). If "they" but know the *seventh* digit of the "fine structure constant," they are ages ahead of us (we know only the first five for sure, suspect the sixth). This number, 137.039 . . . , is the ratio, among others, of the speed of light to the speed of the hydrogen electron; it may take a century to calculate this constant to 9 digits. And after we resolve our pressing scientifie questions, it might be appropriate to make discreet inquiries as to how we could live in harmony and peace with our fellow man—that is, if we aren't eaten or otherwise ingested by the superior civilization that had the good fortune to contact us. But as far as the cryptologist is concerned, he (and generations of his descendants who might experience the supreme

[4] The solution may be found on p. 109; but eschew the premature peek.

[5] With what he has learned from this example of space communication, let the reader formulate these two questions directly for transmission to "them," in a clear and compact form; the solutions appear on pg. 109. For the reader who is a little rusty on classic unsolved problems in mathematics, Fermat's Last Theorem states that no integral values of x, y, and z can be found to satisfy the equation $x^n + y^n = z^n$, if n is an integer greater than 2; Goldbach's "notorious" conjecture ("notorious" only because other mathematicians failed to make the conjecture themselves) states that every even number greater than 2 can be expressed as the sum of two primes.

thrill of their lives when we hear from "them") must keep a level head, not get excited, and be prepared to cope with problems the like of which he has never seen—out of this world, so to speak.

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Extraterrestrial Intelligence

BY HOWARD H. CAMPAIGNE

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Extraterrestrial Communications

In the most recent issue of the NSA Technical Journal- Vol. XI, No. 1- Mr. Lambros D. Callimahos discussed certain aspects of extraterrestrial intelligence and included several messages to test the reader's ingenuity. In the following pages, Dr. H. H. Campaigne offers additional communications from outer space.

Recently a series of radio messages was heard coming from outer space. The transmission was not continuous but was cut by pauses into pieces which could be taken as units, for they were repeated over and over again. The pauses show here as punctuation. The various combinations have been represented by letters of the alphabet, so that the messages can be written down. Each message except the first is given here only once. The serial number of the message has been supplied for each reference.

1. ABCDEFGHJKLMNOPQRSTUV
   ABCDEFGHJKLMNOPQRSTUV
   ABCDEFGHJKLMNOPQR etc.
2. AA, B;AAA,C; AAAA,D; AAAAA,E; AAAAAA,F; AAAAAAA,G.
3. LAA; LBB, LCC; LDD; LEE; LFF; LGG.
4. LBKAA; LCKBA; LCKAB; LDKCA; LDKBB; LDKAC; LEKDA; LEKCB; LEKBC; LEKAD; LFKEA; LFKDB; LFKCC; LFKBD; LFKAE.
5. LFKAKBC; LFKCKBA; LGKAKBD; LGKCKAC; LKAKBCKKABC.
6. LAMBA; LBMCA; LAMCB; LCMDA; LBMDB; LAMDC; LDMEA; LCMEB; LBMEC; LAMED.
7. LNMAA; LNMBB; LNMCC; LNMDD; LNMEE; LNMFF; LNMGG.
8. LAOAA; LNONA; LBOAB; LBOBA; LNONB; LNOBN; LDOBB; LDOAD; LFOAF; LFOBC.
9. LFOAOBC; LFOCOBA; LFOBOCA; LODOEFOODEF.
10. LDRBB; LBRBA; LARBN; LCRCA; LARCN.
11. LRBCKDD; LRBCKAG; LRBCOBD; LRBBD.
12. LRCBKDE; LRCBOCC.
13. LJRBC; LJKAG; LKJAOCC; LKJARCB.
14. LBPJD; LDPJB; LAPCC; LCPFB.

15. UAB; UBC; UCD; UEJ; UFJ; UGJ; URBCRCB.

16. QLNA; QLAC; QLAKAA; QLNOAA; QLRBBB; QUBB; QHLAALAB;
QQLCC; QUJG.

17. SLAA; SUAB; SLBKAA; SLAOAA; SLNMAA; SHLFOAFLAPFF; SHLAALBB.

18. LATA; LBTKATA; LETKBTCT; LFTOCTBT; LGTG; LANTJ.

19. LABCTKOARJBKOBRJAC;
LCBATKOCRJBKOBRJAOARJN;
LDEFGTKKODRJCOERJBKOFRJAOGRJN;

20. HLJKAAVLGAV;
HLAATRCAVLBAV;
HLCAVLAATRAVB;
HLEAVLFKAAV;
HLCKAGOVLBGOV;
HLFOBSOVLCSOV;
HLCDOVLAATRDOVB;
SLKAVPVKPVAV;
SLOAVPVOPVAV;
SLKAVKPVTVKKAVPVTV;
SLOAVOPVSVOOAVPVSV;
HQLAVBVQLMAVBVMBVAV;
HQLAVBVQLRAVBVRBVAV;

21. HLNKBMRDDDVBODDDVCUVLADDDVLBDDDV;
HUVLADVLMNADVLARDVB;
HUVLABVLNBVLNMBVRBVB;
SUVLAVBVQLAVBV;
SUVUAVBVUBVAV.

22. QTVUAVBVUBVAV;
QTVLAVBVQLAVBV;
HTVLRAVBDUNAVLAVB;
HQUAVBVUVUBVAVLBVAV;
SHQTVGVHVUVQGVQHV;
SHQUVGVHVTVQGVQHV;
LUVAVUVBVCVUVUVAVBVCV;
LTVAVTVBVCVTVTVAVBVCV;
LTVAVUVBVCVUVTVAVBVTVAVCV:
LUVAVTVBVCVTVUVAVBVUVAVCV.

23. JNVUVBAVCAVBAV;
JNVBAVTVBAVCAV;
JNVUVBAVCAVTVBAVCAV;
HJNVBAVCAVLBAVUVBAVCAV;
HJNVBAVCAVLCAVTVBAVCAV;
HTVJNVBAVCAVJNVCAVBAVLBAVCAV;
HJNVBAVCAVJNVQCAVQBAV;
SHTVJNVBAVCAVJNVCAVDAVJNVBAVDAV.

24. NKVAJAV;
NKVBJAV;
NKVCJAV;
NKVDJAV;
NKVEJAV;
NKVFJAV;
NKVGJAV;
NKVAATJAV;
NKVABTJAV;
HNKVAVJAVNKVKAVAJAV.

25. NKVTVABJAV;
NKVTVTVABCJAV;
NKVTVADTAGTJAV;
NKVTVTVGGTANNTANATJAV;
HTVJNVAVNMVJNVBVNMVJNVTVAVBVNMV;
NKVNJAV;
NKVJJAV;
NKVRJBJAV;
NKVRJCJAV;
NKVRJDJAV;
NKVRJJJAV;
NKVRJANTJAV;
NKVRJANNTJAV;
NKVRJANNNTJAV;
HNKVBVJAVNKVRJBVJAV;
HNKVTVBVCVJAVNKVKBVCVJAV;
HNKVTVBVCVJAVNKVOBVCVJAV;
HNKVTVBVCVJAVNKVRBVCVJAV;
QNKVPABJAV;
QNKVMABJAV;
QNKVMNCJAV;
QNKVPGFJAV.

26. NKVJAVJOV;
NKVMNAJOV;
HNKVMNBVJAVNKVBVJOV;
NKVPABJOV;
HNKVTVAVBVJOVNKVMAVBVJOV;
HTVNKVTVAVBVJOVQLNBVNKVPAVBVJOV;
QNKVPANJAV;
QNKVPANJOV;
SLOPAVBVPCVDVPOAVCVOBVDV;
SHUOAVDVOBVCVUPAVBVPACVDV, QLOBVDVN;
HNKVAVJAVUMNAAV;

27. HTVHAVBVHBVAVHVAVBV;
HHVAVBVTVHAVBVHBVAV;
HVHVAVBVTVHAVBVHBVAV.

28. HLRGVBCQNKVGVJOV;
HLRGVBBQNKVGVJOV;
HLRGVBEQNKVGVJOV;
HLRGVBENKVGVJEV;
NKVJOVJEV;
NKVJAVJEV;
HLRGVBMNAQNKVGVJEV.

29. NKVMARBMNAJBV;
NKVMARCMNAJBV;
NKVMARDMNAJBV;
NKVMARNVMNAJBV;
LNLVJBVA;
NKVPAAJCV;
NKVPABJCV;
NKVPACJCV;
NKVPANVJCV;
LNLVJCVN;
NKVRMAPABBJBV;
NKVRMAPACCJBV;
NKVRMAPADDJBV;
NKVRMAPARJANNTRJANNTJBV;
NKVRMAPANVNVJBV;
NKVNLVJBVJEV;

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Key To The Extraterrestrial Messages

BY H. CAMPAIGNE

Unclassified

Dr. Campaigne presented a series of 29 messages from outer space in "Extraterrestrial Intelligence," NSA Technical Journal, Vol. XI, No. 2, pp. 101 ff. and in the Special Mathematics and Engineering Issue of the Journal, pp. 117 ff. The following article develops a key to these messages. Paragraph numbers parallel the serial numbers of the messages reprinted in the appendix below. This includes two new series—30 and 31—not included in the previous article.

At every step in the solution we make a guess at the meaning. Evidence will quickly accumulate to verify or refute this guess. The possibility of ambiguity of two consistent solutions is very remote. Only in the last steps, where verification is thin, could this happen.

1. There are 21 symbols, in the order given by this message.

2. B is equivalent to AA, C to AAA, etc. That is, A=1; B=2; C=3; D=4; E=5; F=6; G=7.

3. The symbol L means the two things that follow are the same. LXY means x=y.

4. Each statement has 5 symbols, and begins with L. The 4 symbols after L must be considered as two things. Each statement has a K as the third letter, which must be the start of the second thing. Is B=KAA; C=KBA; C=KAB; D=KCA? If KBA means B+A, it fits.

5. These verify our conclusions on 4. The first means $6=1+(2+3)$, the last means $1+(2+3)=(1+2)+3$.

6. Each has five symbols as in 4. They mean 1=M21; 2=M31; 1=M32. Obviously MXY means $x-y$.

7. These translate N=1−1; N=2−2; N=3−3. N stands for zero, 0.

8. These translate 1=O11; 0=O01; 2=O12; 2=O21; 0=O02; 0=O20; 4=O22, etc. OXY means the product $X \times Y$.

9. These verify the conclusions of 8. The first says that $6=1\times2\times3$, the last $4\times(5\times6) = (4\times5)\times6$.

Note: So far we have seen two kinds of symbols: digits A through G and N, and operators L, K, M, and O. The two digits following the operator are the operands.

10. Translates into 4=R22; 2=R21; 1=R20; 3=R31; 1=R30. RXY must mean X^y, exponentiation. R is another binary operator.

11. Translates into $2^3=4+4$; $2^3=1+7$; $2^3=2\times4$; $2^2=4$, verifying our previous conclusions.

12. Translates into $3^2=4+5$; $3^2=3\times3$. Further verification.

Note: In our culture we use parentheses to group closely associated terms, and as a first step it helps, even though it is not necessary, to put in parentheses. To do so unambiguously, start at the right and read left to the first operator symbol; put parentheses about the operator and the two quantities to its right. Repeat until no pair of parentheses contains more than an operator and two quantities.

13. Translates into $J=2^3$; $J=1+7$; $J+1=3\times3$; $J+1=3^2$, therefore $J=8$.

14. We can only introduce parentheses by assuming P is an operator, so we get $2=P84$; $4=P82$; $1=P33$; and $3=P62$. Thus $P\times Y=X\div Y$, division.

15. Assume U is an operator, getting U12; U23; U34; U58; U68; U78; $U2^33^2=U89$. The smaller is first in each case; so perhaps UXY means X precedes Y or $X<Y$.

16. The new character Q must be an operator. Transcribed it gives us Q: $O=1$; Q: $1=3$; Q: $1=1+1$; Q: $O=1\times1$; Q: $2^2=2$; Q: $2<2$; Q: $H(1=1)\ (1=2)$; Q[Q: $3=3$]; Q: $8<7$.

Clearly Q means "the following statement is false." Then the next to the last is read "it is false that $3\neq3$." QL will be translated $\neq$. The second new symbol is not clear, except that it is an operator whose operands are statements, not quantities, a Boolean operator.

Note: Q is an operator with only one operand, unary.

17. Putting in parentheses shows that S is also a unary operator operating on statements. Transcribed they are: S: $1=1$; S: $1<2$; S: $2=1+1$; S: $1=1\times1$; S: $O=1-1$; S: $H[(6=1\times6)\ (1=6\div6)]$; S: $H[(1=1)\ (2=2)]$. It is apparent that S means "the following statement is true" or "it is asserted that." The next to the last message shows that HXY means "X implies Y" or "X is a consequence of Y" or maybe "X is logically equivalent to Y."

18. Our rule for parentheses breaks down unless T is a different kind of symbol. The first message shows that T may be a unary operator on quantities, so that AT or TA is a quantity. The third message shows that it must be the first, since T is last. Putting in parentheses this way gives $1T=1$; $2T=1T+1$; $5T=2T+3T$; $6T=3T\times2T$; $7T=7$; $10T=8$. T must be an ending. On one digit it makes no difference. It combines the two digits 10 to make 8. Octal arithmetic?

19. Transcribes to $123T=1\times8^2+(2\times8^1+3)$;
$321T=3\times8^2+(2\times8^1+1\times8^0)$;
$4567T=(4\times8^3+5\times8^2)+(6\times8^1+7\times8^0)$.

Clearly T indicates that "the preceding digits form an octal number." Possibly it is an octal point; if so, digits may occur after it.

Note: Because of the way grouping is implied, it is sufficient to have a marker at the end of a number in order to clearly isolate it as a single entity.

20. In trying to put on parentheses it appears that V is also an ending. But this one combines with both quantities (that is, digits,) and operator. Transcribing by treating V and the preceding symbol as a single unit for the time being, we get:

$8 = 1+\mathrm{AV}$ implies $7 = \mathrm{AV}$.

I will use $=\cdot$ for H hereafter. Remember that we are not sure of the sense of this sign. $11 = 3^{AV} =\cdot 2=\mathrm{AV}$ (I have omitted the T. Remember that 11T is nine);

$3 = \mathrm{AV} =\cdot 11 = \overline{\mathrm{AV}}^2$;
$5 = \mathrm{AV} =\cdot 6 = 1+\mathrm{AV}$.

In the next message if we combine the O and V into one symbol the message does not parse. Try GOV as one symbol, getting

$3 = 1+\mathrm{GOV} =\cdot 2 = \mathrm{GOV}$;
$6 = 2\times\mathrm{SOV} =\cdot 3 = \mathrm{SOV}$;
$3 = \mathrm{DOV} =\cdot 11 = \overline{\mathrm{DOV}}^2$;
It is true that $\mathrm{AV}+\mathrm{PV} = \mathrm{PV}+\mathrm{AV}$;
It is a tautology that $\mathrm{AV} \times \mathrm{PV} = \mathrm{PV} \times \mathrm{AV}$;
It is an identity that $\mathrm{AV} + (\mathrm{PV} + \mathrm{TV}) = (\mathrm{AV} + \mathrm{PV}) + \mathrm{TV}$;
It is asserted that $\mathrm{AV} \times (\mathrm{PV} \times \mathrm{TV}) = (\mathrm{AV} + \mathrm{PV}) + \mathrm{TV}$;
$\mathrm{AV} \neq \mathrm{BV} =\cdot \mathrm{AV} - \mathrm{BV} \neq \mathrm{BV}-\mathrm{AV}$;
$\mathrm{AV} \neq \mathrm{BV} =\cdot \mathrm{AV}^{BV} \neq \mathrm{BV}^{AV}$.

The meaning of V must be that "the preceding letters as a group have an abstract meaning, or are a variable." V is a little like a word spacer.

Note: Putting in parentheses is now complicated by another rule. Each T or V should be packaged with preceding symbols, just how many depending on the parsing of the message. Those preceding T will all be digits. Those preceding V can be expected to reoccur as a group.

21. Putting parentheses in these messages is difficult until we notice that UV appears in each. They then transcribe into:

$0=[2+(\overline{\mathrm{DDDV}}^2 - \mathrm{DDDV}\times 3)] =\cdot \mathrm{UV}[1=\mathrm{DDDV}]$
$[2=\mathrm{DDDV}]$;
$\mathrm{UV}[1=\mathrm{DV}][0-1=\mathrm{DV}] =\cdot [1=\overline{\mathrm{DV}}^2]$;
$\mathrm{UV}[1=\mathrm{BV}][0=\mathrm{BV}] =\cdot 0=\mathrm{BV}-\overline{\mathrm{BV}}^2$;
It is true that $\mathrm{UV}[\mathrm{AV}=\mathrm{BV}][\mathrm{AV}\neq\mathrm{BV}]$;
It is true that $\mathrm{UV}[\mathrm{AV}<\mathrm{BV}][\mathrm{BV}<\mathrm{AV}]$.

In order to complete the parsing we had to assume that UV was a binary operator, and in every case the operands are statements. It is clear from the algebra that UV means "or." The last message shows that U means $\leq$, rather than $<$ as I had it.

22. We notice that TV is used in every message, and parallels the usage of UV. Assuming TV is a binary Boolean operator, the messages parse.

It is false that TV[$AV \leq BV$][$BV \leq AV$];
It is false that TV[$AV = BV$][$AV \neq BV$];
TV[$\overline{AV}^2 = 4$][$0 \leq AV$] $= \cdot$ $AV = 2$;
$AV > BV$ $= \cdot$ [$BV \leq AV$] or [$BV = AV$];
It is true that not TV GV HV $= \cdot$ GV or HV;
It is true that GV and HV $= \cdot$ TV GV HV;
AV or (BV or CV) = (AV or BV) or CV;
TV[AV TV[BVCV]] = TV[[TV AV BV]CV];
TV[AV[BV or CV]] = TV[AVBV] or TV[AV CV];
AV or TV [BV CV] = TV[AV or BV][AV or CV].

It is apparent that TV means "and." Notice that L is used here to mean "logically equivalent to," although I have written "=".

Note: U is used here for $<$, not $\leq$.

Either there is a mistake, or the usage varies.

23. The parsing falters until we realize that JNV occurs in each message, and is probably a word. BAV and CAV also occur in each message. They transcribe into:

JNV [BAV or CAV] BAV;
JNV BAV [BAV and CAV];
JNV [BAV or CAV][BAV and CAV];
JNV BAV CAV $= \cdot$ BAV = (BAV or CAV);
JNV BAV CAV $= \cdot$ CAV = (BAV and CAV).

The last two conclusions look like set theory statements. JNV parses like a binary operator. JNV XY could mean "X contains Y" in the set theory sense. Then if UV is "or" in the set theory sense, the union, and TV is "and" in the set theory sense, the intersection, the statements above can be rewritten:

$BAV \cup CAV \supset BAV$
$BAV \supset BAV \cap CAV$
$BAV \cup CAV \supset BAV \cap CAV$
$BAV \supset CAV = \cdot\ BAV = (BAV \cup CAV)$
$BAV \supset CAV = \cdot\ CAV = (BAV \cap CAV)$.

24. NKV looks like a binary operator of which at least the first operand is a quantity. JAV is uniformly the second operand. From 23 above we are alert to set theory statements. Could it be that NKV says something is a member of some set? Try it. They become

$1 \epsilon JAV$; $2 \epsilon JAV$; $3 \epsilon JAV$; $4 \epsilon JAV$; $5 \epsilon JAV$; $6 \epsilon JAV$; $7 \epsilon JAV$; $11 \epsilon JAV$; $12 \epsilon JAV$; $AV \epsilon JAV = \cdot\ AV + 1 \epsilon JAV$.

JAV is the set of positive integers! It fits!

25. These parse into:
(1 and 2)ϵ JAV;
((1 and 2) and 3)ϵ JAV;
(14 and 17)ϵ JAV;
((77 and 100) and 101)ϵ JAV;
(AV $\supset$ NMV) and (BV $\supset$ NMV) $= \cdot$ (AV and BV) $\supset$ NMV;
0ϵJAV;
8ϵJAV; $8^2\epsilon$JAV; $8^3\epsilon$JAV; $8^4\epsilon$JAV; $8^8\epsilon$JAV; $8^{10}\epsilon$JAV; $8^{100}\epsilon$JAV;
$8^{1000}\epsilon$JAV; BVϵJAV $= \cdot$ $8^{BV}\epsilon$JAV;
(BV and CV)ϵJAV $= \cdot$ BV$+$CVϵJAV;
(BV and CV)ϵJAV $= \cdot$ BV$\times$CVϵJAV;
(BV and CV)ϵJAV $= \cdot$ $BV^{CV}\epsilon$JAV;
1/2$\not\epsilon$JAV; $1-2\not\epsilon$JAV; $0-3\not\epsilon$JAV; 7/6$\not\epsilon$JAV.

This verifies beyond doubt the guess of 24.

26. There is a new word, JOV. The messages read JAVϵJOV;
$0-1\epsilon$JOV; $0-$BVϵJAV $= \cdot$ BVϵJOV;
1/2ϵJOV; AV and BVϵJOV $= \cdot$ AV$-$BVϵJOV;
(AV and BV in JOV) and $0 \neq$ BV $= \cdot$ AV $\div$ BV in JOV;
$1 \div 0$ not in JAV; $1 \div 0$ not in JOV;
It is true that (AV $\div$ BV) $\times$ (CV $\div$ DV) $=$ (AV $\times$ CV) $\div$ (BV $\times$ DV);
It is true that AV $\times$ DV $<$ BV $\times$ CV $= \cdot$ AV $\div$ BV $<$ CV $\div$ DV, BV $\times$ DV $\neq 0$;
AVϵJAV $= \cdot$ $0-1<$AV.

JOV is seen to be the field generated by JAV, in other words, the set of rational numbers. The next to the last message has a garble, an extraneous A.

27. This transcribes to:
(AV $= \cdot$ BV) and (BV $= \cdot$ AV) $= \cdot$ HV.AV.BV.
Clearly HV means "logically equivalent," or "$\cdot = \cdot$".
(AV $\cdot = \cdot$ BV) $= \cdot$ (AV $= \cdot$ BV) and (BV $= \cdot$ AV)
(AV $\cdot = \cdot$ BV) $\cdot = \cdot$ (AV $= \cdot$ BV) and (BV $= \cdot$ AV).

28. These transcribe to
$\overline{GV}^2 = 3 = \cdot$ GV not in JOV;
$\overline{GV}^2 = 2 = \cdot$ GV not in JOV;
$\overline{GV}^2 = 5 = \cdot$ GV not in JOV;
$GV^2 = 5 = \cdot$ GV in JEV;
JOV is in JEV;
JAV is in JEV;
$\overline{GV}^2 = 0-1 = \cdot$ GV not in JEV.

We have a new set, containing the rationals, and at least one irrational, but not the imaginary $\sqrt{-1}$. JEV is probably the real numbers.

29. These transcribe to
$1-2^{0-1}$ in JBV; $1-3^{0-1}$ in JBV;
$1-4^{0-1}$ in JBV; $1-\overline{NV}^{0-1}$ in JBV;
NLV JBV = 1 [assuming NLV is one word. Another possible parsing is LV(JBV, 1) = 0]
1/1 in JCV; 1/2 in JCV; 1/3 in JCV; 1/NV in JCV; NLV JCV = O [or LV (JCV, O) = O. But the two examples suggest that NLV means "a limit of." If NV is an integer this fits perfectly.]
$(1-1/2)^2$ in JBV; $(1-1/3)^3$ in JBV;
$(1-1/4)^4$ in JBV; $\left(1-\frac{1}{8^{100}}\right)^{8^{100}}$ in JBV;
$\left(1-\frac{1}{NV}\right)^{NV}$ in JBV; NLV JBV in JEV.
If NLV means limit, then JEV contains the number e, a verification of our guess that JEV named the real numbers.
The last two lessons—30 and 31—were not published with the first twenty-nine because it made too long an exercise.

30. The later messages of this group have the mysterious sequences ABCD, ABCDE, DEFG, etc, each ending with STV. If we bunch these each as a unit, the messages parse. They then say JNV 1 natural number; JNV 2 natural number; JNV 3 natural number; JNV 123 STV natural number; conjecture STV means "the preceding is a set (or sequence)," and JNV means "belongs to." There is doubt about the latter, since we thought earlier that it meant "contains"; AV belongs to 1234 =· AV is a natural number; 12345 or 4567 = 45 as sets; 12345 and 4567 = 1234567 as sets.

31. This last group is of impressive magnitude, 41 messages, of which the thirtieth is quite long. Parsing is eased by the parallel construction of the messages. They transcribe to:

JRAV belongs to CHAV; JRBV belongs to CHAV; JRGV belongs to CHAV; the set JRAV, JRBV, JRCV, JRDV, JREV, JRFV, JRGV belongs to CHAV; [Since all the digits appear in these groups, maybe they are used like subscripts and should be read JR_1, JR_2, etc.]; JO_1 belongs to CHAV; JO_2 belongs to CHAV; JO_{22} belongs to CHAV; the set JO_1, JO_2, JO_3, JO_4, JO_5, JO_6, JO_7, JO_{10}, JO_{11}, JO_{12}, JO_{13}, JO_{14}, JO_{15}, JO_{16}, JO_{17}, JO_{20}, JO_{21}, JO_{22} belongs to CHAV; U_{01} and U_1 =· 22 JO_1 belongs to CHAV [This one must be parsed wrong or garbled]; BL_1 belongs to JR_1; BL_2 belongs to JR_1; BL_3 belongs to JR_2; BL_4 belongs to JR_2; BL_{12} belongs to JR_2;
$AV \geq 3$ and $12 \geq AV$ ·=· BL_{AV} belongs to JR_2;
$AV \geq 13$ and $22 \geq AV$ ·=· BL_{AV} belongs to JR_3;
$AV \geq 23$ and $44 \geq AV$ ·=· BL_{AV} belongs to JR_4;

$AV \geq 45$ and $66 \geq AV \cdot = \cdot BL_{AV}$ belongs to JR_5;
$AV \geq 67$ and $126 \geq AV \cdot = \cdot BL_{AV}$ belongs to JR_6;
$AV \geq 127$ and $142 \geq AV \cdot = \cdot BL_{AV}$ belongs to JR_7;
The set BL_1, BL_3, BL_{13}, BL_{23}, BL_{45}, BL_{67}, BL_{127} belongs to JO_1;
The set BL_2, BL_4, BL_{14}, BL_{24}, BL_{46}, BL_{70}, BL_{130} belongs to JO_2;
The set BL_5, BL_{15}, BL_{37}, BL_{61}, BL_{121} belongs to JO_3;
The set BL_6 and BL_{16} and BL_{40} and BL_{62} and BL_{122} belongs to JO_4;
The set BL_7, BL_{17}, BL_{41}, BL_{63}, BL_{123} belongs to JO_5;
The set BL_{100}, BL_{20}, BL_{42}, BL_{64}, BL_{124} belongs to JO_6 [note a garble here, an N is repeated];
The set BL_{11}, BL_{21}, BL_{43}, BL_{65}, BL_{125} belongs to JO_7;
The set BL_{12}, BL_{22}, BL_{44}, BL_{66}, BL_{126} belongs to JO_{10};
The set BL_{25}, BL_{47}, BL_{71}, BL_{72}, BL_{73}, BL_{74}, BL_{75}, BL_{76}, BL_{77}, BL_{100}, BL_{101}, BL_{102}, BL_{103}, BL_{104}, BL_{105}, BL_{106}, BL_{107}, BL_{131}, BL_{132}, BL_{133}, BL_{134}, BL_{135}, BL_{136}, BL_{137}, BL_{140}, BL_{141}, BL_{142} belongs to JO_{11};
BL_{16} and BL_{50} and BL_{110} belongs to JO_{12};
The set BL_{27}, BL_{51}, BL_{111} belongs to JO_{13};
The set BL_{30}, BL_{52}, BL_{112} belongs to JO_{14};
The set BL_{31}, BL_{53}, BL_{113} belongs to JO_{15};
The set BL_{32}, BL_{54}, BL_{114} belongs to JO_{16};
The set BL_{33}, BL_{55}, BL_{115} belongs to JO_{17};
The set BL_{34}, BL_{56}, BL_{116} belongs to JO_{20};
The set BL_{35}, BL_{57}, BL_{117} belongs to JO_{21};
The set BL_{36}, BL_{60}, BL_{120} belongs to JO_{22};
CHAV belongs to KSPV.

The transcription leaves a lot to be resolved. There are several words the meanings of which are yet to be determined. The word CHAV (or CH_1) seems to be central. There are seven words JR_x and eighteen words JO_y, and each of these belongs to CHAV. There are 98 words BL_z, each of which seems to belong to a unique JO_y. Does each also belong to a unique JR_x? With this hint we can straighten out the garbled message above; it reads "$0 < AV$ and $AV < 22 = \cdot JO_{AV}$ belongs to CHAV"; there was a V omitted. I was also able to reparse six other messages. I will not bore you with the details, since the list above has been corrected.

Since each BL_Z belongs to one JR_x and JO_y, these can be displayed in a matrix

	JR_1	JR_2	JR_3	JR_4	JR_5	JR_6	JR_7
JO_1	BL_1	BL_3	BL_{13}	BL_{23}	BL_{45}	BL_{67}	BL_{127}
JO_2	BL_2	BL_4	BL_{14}	BL_{24}	BL_{46}	BL_{70}	BL_{130}
JO_3		BL_5	BL_{15}	BL_{37}	BL_{61}	BL_{121}	
JO_4		BL_6	BL_{16}	BL_{40}	BL_{62}	BL_{122}	
JO_5		BL_7	BL_{17}	BL_{41}	BL_{63}	BL_{123}	
JO_6		BL_{10}	BL_{20}	BL_{42}	BL_{64}	BL_{124}	

JO_7	BL_{11}	BL_{21}	BL_{43}	BL_{65}	BL_{125}					
JO_{10}	BL_{12}	BL_{22}	BL_{44}	BL_{66}	BL_{126}					
JO_{11}	BL	25	47	71	72	73	74	75	76	77
	100	101	102	103	104	105	106	107		
		131	132	133	134	135	136	137		
	140	141	142							
JO_{12}	BL_{16}			BL_{50}	BL_{110}					
JO_{13}			BL_{27}	BL_{51}	BL_{111}					
JO_{14}			BL_{30}	BL_{52}	BL_{112}					
JO_{15}			BL_{31}	BL_{53}	BL_{113}					
JO_{16}			BL_{32}	BL_{54}	BL_{114}					
JO_{17}			BL_{33}	BL_{55}	BL_{115}					
JO_{20}			BL_{34}	BL_{56}	BL_{116}					
JO_{21}			BL_{35}	BL_{57}	BL_{117}					
JO_{22}			BL_{36}	BL_{60}	BL_{120}					

Remember that these are not decimal numbers. There is only one cell with more than one entry, and the subscripts in it in decimal notation are 21, 39, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98. The larger part of the entries is systematically distributed in the first eight rows. This suggests the periodic table of the chemical elements! On consulting a table we find, sure enough, that elements 57 through 71 are rare earths, and are lumped into one cell. Some, but not all, authorities also list 89 through 103 as rare earths. Elements 21 and 39 are Scandium and Yttrium.

CHAV must mean the periodic table. JR_x means column x, and JO_y means row y. BL_Z means element Z. The meaning of KSPV is not known, except that it is a generalization of "periodic table." It may merely mean table, or scientific fact, or university subject.

Looking back over the exercise we see we have penetrated the meaning of the basic symbols, and even more important, have learned some of the syntax rules of the notation, and have caught mistakes in the process. We have a few words for sophisticated concepts, and, given more data, with a little labor we could establish its translation.

The concepts used here are the basic ones of number, sets, and physical constants which any cultures must share. How bizarre the syntax and values of a culture could be I cannot conjecture, but any civilizations capable of sending a message across space must have many things in common.

APPENDIX

Recently a series of radio *messages* was heard *coming* from *outer* space. The transmission was not continuous, but cut by pauses into pieces which could be taken as units, for they were repeated over and over again. The pauses show here as punctuation. The various combinations have been represented by letters of the alphabet, so that the messages can be written down. Each message except the first is given here only once. The serial number of the message has been supplied for each reference.

1. ABCDEFGHJKLMNOPQRSTUV
   ABCDEFGHJKLMNOPQRSTUV
   ABCDEFGHJKLMNOPQR etc.
2. AA. B; AAA.C; AAAA.D; AAAAA.E; AAAAAA.F. AAAAAAA.G.
3. LAA; LBB. LCC; LDD; LEE; LFF; LGG.
4. LBKAA; LCKBA; LCKAB; LDKCA; LDKBB; LDKAC; LEKDA; LEKCB; LEKBC; LEKAD; LFKEA; LFKDB; LFKCC; LFKBD; LFKAE
5. LFKAKBC; LFKCKBA; LGKAKBD; LGKCKAC; LKAKBCKKABC.
6. LAMBA; LBMCA; LAMCB; LCMDA; LBMDB; LAMDC; LDMEA; LCMEB; LBMEC; LAMED.
7. LNMAA. LNMBB; LNMCC; LNMDD; LNMEE; LNMFF; LNMGG.
8. LAOAA; LNONA; LBOAB; LBOBA; LNONB; LNOBN; LDOBB; LDOAD; LFOAF; LFOBC.
9. LFOAOBC; LFOCOBA; LFOBOCA; LODOEFOODEF.
10. LDRBB; LBRBA; LARBN; LCRCA; LARCN.
11. LRBCKDD; LRBCKAG; LRBCOBD; LRBBD.
12. LRCBKDE; LRCBOCC.
13. LJRBC; LJKAG; LKJAOCC; LKJARCB.
14. LBPJD; LDPJB; LAPCC; LCPFB.
15. UAB; UBC; UCD; UEJ; UFJ; UGJ; URBCRCB.
16. QLNA; QLAC; QLAKAA; QLNOAA; QLRBBB; QUBB; QHLAALAB; QQLCC; QUJG.
17. SLAA; SUAB; SLBKAA; SLAOAA; SLNMAA; SHLFOAFLAPFF; SHLAALBB.
18. LATA; LBTKATA; LETKBTCT; LFTOCTBT; LGTG; LANTJ.
19. LABCTKOARJBKOBRJAC;
    LCBATKOCRJBKOBRJAOARJN;
    LDEFGTKKODRJCOERJBKOFRJAOGRJN;
20. HLJKAAVLGAV;
    HLAATRCAVLBAV;
    HLCAVLAATRAVB.
    HLEAVLFKAAV;
    HLCKAGOVLBGOV;
    HLFOBSOVLCSOV;
    HLCDOVLAATRDOVB;
    SLKAVPVKPVAV.
    SLOAVPVOPVAV;
    SLKAVKPVTVKKAVPVTV;
    SLOAVOPVSVOOAVPVSV;
    HQLAVBVQLMAVBVMBVAV;
    HQLAVBVQLRAVBVRBVAV.
21. HLNKBMRDDDVBODDDVCUVLADDDVLBDDDV;
    HUVLADVLMNADVLARDVB;
    HUVLABVLNBVLNMBVRBVB;

SUVLAVBVQLAVBV;
SUVUAVBVUBVAV

22. QTVUAVBVUBVAV;
QTVLAVBVQLAVBV;
HTVLRAVBDUNAVLAVB.
HQUAVBVUVUBVAVLBVAV;
SHQTVGVHVUVQGVQHV;
SHQUVGVHVTVQGVQHV.
LUVAVUVBVCVUVUVAVBVCV.
LTVAVTVBVCVTVTVAVBVCV;
LTVAVUVBVCVUVTVAVBVTVAVCV.
LUVAVTVBVCVTVUVAVBVUVAVCV.

23. JNVUVBAVCAVBAV.
JNVBAVTVBAVCAV.
JNVUVBAVCAVTVBAVCAV.
HJNVBAVCAVLBAVUVBAVCAV;
HJNVBAVCAVLCAVTVBAVCAV;
HTVJNVBAVCAVJNVCAVBAVLBAVCAV.
HJNVBAVCAVJNVQCAVQBAV;
SHTVJNVBAVCAVJNVCAVDAVJNVBAVDAV.

24. NKVAJAV;
NKVBJAV;
NKVCJAV;
NKVDJAV;
NKVEJAV;
NKVFJAV,
NKVGJAV;
NKVAATJAV;
NKVABTJAV;
HNKVAVJAVNKVKAVAJAV.

25 NKVTVABJAV.
NKVTVTVABCJAV;
NKVTVADTAGTJAV;
NKVTVTVGGTANNTANATJAV;
HTVJNVAVNMVJNVBVNMVJNVTVAVBVNMV;
NKVNJAV;
NKVJJAV;
NKVRJBJAV;
NKVRJCJAV;
NKVRJDJAV.
NKVRJJJAV.
NKVRJANTJAV.
NKVRJANNTJAV;
NKVRJANNNTJAV;
HNKVBVJAVNKVRJBVJAV;
HNKVTVBVCVJAVNKVKBVCVJAV.
HNKVTVBVCVJAVNKVOBVCVJAV.
HNKVTVBVCVJAVNKVRBVCVJAV.
QNKVPABJAV.
QNKVMABJAV;
QNKVMNCJAV;
QNKVPGFJAV.

26. NKVJAVJOV;
NKVMNAJOV;
HNKVMNBVJAVNKVBVJOV;
NKVPABJOV;
HNKVTVAVBVJOVNKVMAVBVJOV;
HTVNKVTVAVBVJOVQLNBVNKVPAVBVJOV,
QNKVPANJAV.
QNKVPANJOV;
SLOPAVBVPCVDVPOAVCVOBVDV;
SHUOAVDVOBVCVUPAVBVPACVDV.QLOBVDVN;
HNKVAVJAVUMNAAV;

27 HTVHAVBVHBVAVHVAVBV;
HHVAVBVTVHAVBVHBVAV;
HVHVAVBVTVHAVBVHBVAV

28. HLRGVBCQNKVGVJOV;
HLRGVBBQNKVGVJOV;
HLRGVBEQNKVGVJOV;
HLRGVBENKVGVJEV;
NKVJOVJEV;
NKVJAVJEV;
HLRGVBMNAQNKVGVJEV.

29. NKVMARBMNAJBV;
NKVMARCMNAJBV;
NKVMARDMNAJBV;
NKVMARNVMNAJBV;
LNLVJBVA;
NKVPAAJCV;
NKVPABJCV;
NKVPACJCV;
NKVPANVJCV.
LNLVJCVN;
NKVRMAPABBJBV;
NKVRMAPACCJBV;
NKVRMAPADDJBV;
NKVRMAPARJANNTRJANNTJBV;
NKVRMAPANVNVJBV;
NKVNLVJBVJEV;

30. JNVAJAV;
JNVBJAV;
JNVCJAV;
JNVABCSTVJAV;
HJNVAVABCDSTVJNVAVJAV;
LUVABGDESTVDEFGSTVDESTV;
LTVABCDESTVDEFGSTVABCDEFGSTV;

31. JNVJRAVCHAV;
JNVJRBVCHAV;
JNVJRGVCHAV;
JNVJRAVJRBVJRCVJRDVJREVJRFVJRGVSTVCHAV;
JNVJOAVCHAV;
JNVJOBVCHAV;
JNVJOBBVCHAV;

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JNVJOAVJOBVJOCVJODVJOEVJOFVJOGV
JOANVJOAAVJOABVJOACVJOADVJOAEVJOAFVJOAGV-
JOBNVJOBAVJOBBVSTVCHAV:
HTVUNAVUAVBBTJNVJOAVVCHAV:
JNVBLAVJRAV:
JNVBLBVJRAV:
JNVBLCVJRBV:
JNVBLDVJRBV;
JNVBLABVJRBV:
HVTVQUAVCQUABTAVJNVBLAVVJRBV.
HVTVQUAVACTQUBBTAVJNVBLAVVJRCV:
HVTVQUAVBCTQUDDTAVJNVBLAVVJRDV;
HVTVQAVDETQUFFTAVJNVBLAVVJREV:
HVTVQUAVFGTQUABFTAVJNVBLAVVJRFV;
HVTVQUAVABGTQUADBTAVJNVBLAVVJRGV;
JNVBLAVBLCVBLACVBLBCVBLDEVBLFGV-
BLABGVSTVJOAV;
JNVBLBVBLDVBLADVBLBDVBLDFV-
BLGNVBLACNVSTVJOBV;
JNVBLEVBLAEVBLCGVBLFAVBLABAVSTVJOCV:
JNVTVTVTVTVBLFVBLAFVBLDNVBLFBVBLABBVSTVJODV:
JNVBLGVBLAGVBLDAVBLFCVBLABCVSTVJOEV:
JNVBLANNBLBNVBLDBVBLFDVBLABDVSTVJOFV;
JNVBLAAVBLBAVBLDCVBLFEVBLABEVSTVJOGV;
JNVBLABVBLBBVBLDDVBLFFVBLABFVSTVJOANV;
JNVBLBEVBLDGVBLGAVBLGBVBLGCVBLGDV-
BLGEVBLGFVBLGGVBLANNVBLANAVBLANBVBLANCV-
BLANDVBLANEVBLANFVBLANGVBLACAVBLACBV-
BLACCVBLACDVBLACEVBLACFVBLACGVBLADNV-
BLADAVBLADBVSTVJOAAV:
JNVTVTVBLBFVBLENVBLAANVJOABV;
JNVBLBGVBLEAVBLAAAVSTVJOACV;
JNVBLCNVBLEBVBLAABVSTVJOADV;
JNVBLCAVBLECVBLAACVSTVJOAEV;
JNVBLCBVBLEDVBLAADVSTVJOAFV;
JNVBLCCVBLEEVBLAAEVSTVJOAGV;
JNVBLCDVBLEFVBLAAFVSTVJOBNV;
JNVBLCEVBLEGVBLAAGVSTVJOBAV;
JNVBLCFVBLFNVBLABNVSTVJOBBV;
JNVCHAVKSPV.
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