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Key To The Extraterrestrial Messages

BY H. CAMPAIGNE

Unclassified

Dr. Campagne 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; N = 2 - 2; N = 3 - 3. N stands for zero.

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

9. These verify the conclusions of 8. The first says that 6 = 1 × 2 × 3; the last 4 × (5 × 6) = (4 × 5) × 6.

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 X², exponentiation. R is another binary operator.

13
11. Translates into $2^4 + 4 + 2^4 - 1 + 7$; $2^4 - 2 	imes 4$; $2^4 - 4$, verifying our previous conclusions.

12. Translates into $3^4 - 4 + 5; 3^4 - 33$. 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 $J = 2^2; J = 1 + 7; J + 1 - 3 + 3; J + 1 = 3$, therefore $J = 8$.

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

15. Assume $U$ is an operator, getting $U12; U23; U34; U58; U68; U78; U2a3 = U89$. The smaller is first in each case; so perhaps $UXY$ means $X$ precedes $Y$ or $X < Y$.

16. The new character $Q$ must be a character. Transcribed it gives us $Q: O = 1; Q: 1 = 3; Q: 1 = 1 + 1; Q: 0 = 1 \times 1; Q: 2^2 = 2; Q: 2 \times 2; Q: H \{1 = 1 \} (1 = 2); Q[Q: 3 = 3]; Q: 8 < 7$.

Clearly $Q$ means "the following statement is false." Then the next to the last is read "it is false that $3 \neq 3." QL$ 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: $S: 1 - 1; S: 1 - 2; S: 2 = 1 + 1; S: 1 = 1 \times 1; S: 0 = 1 - 1; S: H\{6 - 1 \times 6 \{1 - 6 - 6\}\}; S: H\{1 - 1\} (2 - 2)\}$. It is apparent that $S$ means "the following statement is true" or "it is asserted that." The next to the first shows that $UXY$ 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 $T^A$ 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 $T^A = 1; 2T^A = 1T^A + 1; 5T^A = 2T^A + 3T^A; 6T^A = 3T^A \times 2T^A; 7T^A = 7; 10T^A = 8$. $T$ 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 $123T = 1 \times 8^2 + (2 \times 8^1 + 3); 321T = 3 \times 8^2 + (2 \times 8^1 + 1 \times 8^0); 4567T = (4 \times 8^1 + 5 \times 8^0) + (6 \times 8^0 + 7 \times 8^0)$.

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 + AV implies 7 = AV.

I will use . . for 11 hereafter. Remember that we are not sure of the sense of this sign. 11 . . 311 = . . 2 = AV (I have omitted the V. Remember that V is nine; 3 AV = 6 11 = AV; 5 AV = 6 11 = 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 + GOV . . 2 = GOV;
6 2 x SOV . . 3 = SOV;
3 DOV . . 11 = DOV

It is true that AV = PV = PV x AV;
It is a tautology that AV = PV + AV;
It is an identity that AV = PV + TV = (AV + PV) + TV;
It is asserted that AV = PV x TV = (AV + PV) + TV;
AV > BV = . . AV = BV = BV = BV
AV = AV = AV = BV

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 + (DDV] = . UV [1 = DDV]
[2 + DDV];
UV [1 = UV [1 = UV = . [1 = DDV];
UV [1 = BV] [0 = BV = . 0 = BV = BV;
It is true that UV = BV = BV = BV
It is true that UV = BV = BV = BV

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 < , 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 $TV[AV \leq BV \iff BV \leq AV]$;
It is false that $TV[AV = BV \iff AV \neq BV]$;
$TV[AV = 4] \iff 0 \leq AV \iff AV = 2$;
$AV > BV \iff \lnot (|BV \leq AV \lor |BV = AV|)$;
It is true that not $TV GV HV = \lnot GV$ or $HV$;
It is true that $GV$ and $HV = \lnot TV GV HV$;
$AV \lor (BV or CV) = (AV or BV) or CV$;
$TV[AV TV]\lnot[BCV] = TV[TV AV BV][CV]$;
$TV[AV]BV or CV[CV] = TV[AVBV] or TV[AV CV]$;
$AV or TV[|BV CV| = TV[AV or BV][|AV or CV|]$.

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 = \lnot BAV = (BAV or CAV);
JNV BAV CAV = \lnot 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 = \lnot BAV = (BAV \cup CAV)
BAV \cup CAV = \lnot 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

1cJAV; 2cJAV; 3cJAV; 4cJAV; 5cJAV; 6cJAV; 7cJAV; 11cJAV;
12cJAV; AVG = \lnot AV + 1cJAV;
JAV is the set of positive integers! It fits!
25. These parse into:
(1 and 2) 4 JAV;
(11 and 2) and 3 4 JAV;
(14 and 17) 4 JAV;
(72 and 100) and 101 4 JAV;

(AV ⊕ NMIV) and (BV ⊕ NMIV) = (AV and BV) ⊕ NMIV;
0 4 JAV;

8 4 JAV; 8 4 JAV; 8 4 JAV; 8 4 JAV; 8 4 JAV; 8 4 JAV;

(BV and CV) 4 JAV = (BV) CV 4 JAV;
(BV and CV) 4 JAV = (BV CV) 4 JAV;
(BV and CV) 4 JAV = (BV) CV 4 JAV;

1/2 4 JAV; 1 - 2 4 JAV; 0 - 3 4 JAV; 7/6 4 JAV.

This verifies beyond doubt the guess of 24.

26. There is a new word, JOV. The messages read JAV or JOV:

0 1 4 JOV; 0 4 BV 4 JAV = 4 BV 4 JOV;
1 2 4 JOV; AV and BV 4 JAV = 4 AV - BV 4 JOV;
(AV and BV in JOV) and 0 4 BV = 4 AV + BV in JOV;
1 = 0 not in JAV; 1 = 0 not in JOV;

It is true that (AV + BV) (CV + DV) = (AV CV) (BV + DV);

It is true that AV × DV < BV × CV = AV + BV < UV:

DV, BV × DV < 0;

AV 4 JAV . 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 = - BV) and (BV = AV) = - HV, AV, BV.

Clearly HV means "logically equivalent," or "⇒ .

(AV = - BV) = - (AV = BV) and (BV = AV)

(AV = - BV) = - (AV = BV) and (BV = AV).

28. These transcribe to

\[ \begin{array}{ll}
G^2 & = 1 \Rightarrow GV \text{ not in JOV;}
G^2 & = 2 \Rightarrow GV \text{ not in JOV;}
G^2 & = 5 \Rightarrow GV \text{ not in JOV;}
G^2 & = 1 \Rightarrow GV \text{ in JEV;}
\end{array} \]

JOV is in JEV;
JAV is in JEV;

\[ \begin{array}{ll}
G^2 & = 0 - 1 = GV \text{ not in JEV.}
\end{array} \]

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 $2^i$ in JBV; $1 - 3^i$ in JBV;
1 $4^i$ in JBV; $1 - NV^i$ in JBV;

If $NV$ is a word. Another possible

$1/1$ in JCV; $1/2$ in JCV; $1/3$ in JCV; $1/NV$ in JCV; $NV$ in JCV

But the two examples suggest that

If $NV$ means "a limit of," if $NV$ is an integer this fits

perfectly.

(1) $1/2^i$ in JBV; $(1 - 1/3)^i$ in JBV;

(1) $1/4^i$ in JBV; $\left(1 - \frac{1}{8^{10}}\right)^{100}$ in JBV;

$\left(1 - \frac{1}{NV}\right)^{NV}$ in JBV; $NV$ in JCV.

If $NV$ means limit, then JCV contains the number $e$, a

verification of our guess that JCV 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

ABC1, ABCDE, DEFG, etc, each ending with STL. If we bunch these

each as a unit, the messages parse. They then say $NV$ 1 natural

number; $NV$ 2 natural number; $NV$ 3 natural number; $NV$ 123 STL

natural number; conjecture STL means "the preceding is a set (or

sequence)," and JCV means "belongs to." There is doubt about the

latter, since we thought earlier that it meant "contains"; AV belongs
to $1234 \cdots$ 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; JRV belongs to CHAV; JRGV belongs to

CHA; the set JRAV, JRV, JCV, JRDV, JREF, JREF, JRGV belongs to

CHA; [Since all the digits appear in these groups, maybe

they are used like subscripts and should be read JR, Jr, etc.]; Jo,

belongs to CHAV; Jo, belongs to CHAV; Jo, belongs to CHAV; the

set Jo, Jo, Jo, Jo, Jo, Jo, Jo, Jo, Jo, Jo, Jo, Jo, Jo, Jo, Jo, Jo, Jo, Jo, Jo,

Jo, Jo, Jo, Jo, Jo, Jo, Jo, Jo, Jo, belongs to CHAV; Uu, and $U = \cdots$

22 Jo, belongs to CHAV [This one must be parsed wrong or garbled];

BL, belongs to JR; BL, belongs to JR; BL, belongs to JR; BL, belongs to JR;

AV < 3 and $12 \geq AV \cdots$ BL, belongs to JR;

AV < 13 and $22 \cdot AV \cdots$ BL, belongs to JR;

AV < 23 and $44 < AV \cdots$ BL, belongs to JR.
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) seems to be central. There are seven words JR, and eighteen words JO, and each of these belongs to CHAV. There are 98 words BL, each of which seems to belong to a unique JO. Does each also belong to a unique JR? With this hint we can straighten out the garbled message above; it reads "0<AV and AV<22 = JO11 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 belongs to one JR, and JO, these can be displayed in a matrix:

<table>
<thead>
<tr>
<th>JR1</th>
<th>JR2</th>
<th>JR3</th>
<th>JR4</th>
<th>JR5</th>
<th>JR6</th>
<th>JR7</th>
</tr>
</thead>
<tbody>
<tr>
<td>JO1</td>
<td>BL1</td>
<td>BL2</td>
<td>BL3</td>
<td>BL4</td>
<td>BL5</td>
<td>BL6</td>
</tr>
<tr>
<td>JO2</td>
<td>BL7</td>
<td>BL8</td>
<td>BL9</td>
<td>BL10</td>
<td>BL11</td>
<td>BL12</td>
</tr>
<tr>
<td>JO3</td>
<td>BL13</td>
<td>BL14</td>
<td>BL15</td>
<td>BL16</td>
<td>BL17</td>
<td>BL18</td>
</tr>
<tr>
<td>JO4</td>
<td>BL19</td>
<td>BL20</td>
<td>BL21</td>
<td>BL22</td>
<td>BL23</td>
<td>BL24</td>
</tr>
<tr>
<td>JO5</td>
<td>BL25</td>
<td>BL26</td>
<td>BL27</td>
<td>BL28</td>
<td>BL29</td>
<td>BL30</td>
</tr>
<tr>
<td>JO6</td>
<td>BL31</td>
<td>BL32</td>
<td>BL33</td>
<td>BL34</td>
<td>BL35</td>
<td>BL36</td>
</tr>
</tbody>
</table>
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 system-
atically 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, means column x, and JO,
means row y. BL_x 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

ARCABCGLIKMNOPLQRSTUVWXYZ

2

AA ABACB DCB E CDDDD E F FFFFG G

3

LAAA LBB LCC LDD LEE LFF LGG

4

LTKAAA LKKBA LKKB LKCCA LKddA LKkke LKkke LKkad LKEAA LKEAB LKEBB LKEBB LKKEE

5

LKKKAK LKKnka LKKnKB LKKKCA LKKKCB LKKKABC

6

LAMBA LAMCA LAMCB LAMDA LAMDAB LAMDAB LAMEC LAMEC LAMED

7

LMNAA LMNBH LMNCC LMNDD LMNDE LMNFH LNNFF LNNNG

8

LANAA LANNA LBOAB LBOBA LNOBN LDDBB LDDBD LDOAF LFBOC

9

LFQAOBC LFUBOA LFUCBC LODEPFOOEF

10

LRRBB LRRBA LRRBR LRRCA LRRCN

11

LBBKBBI LBBKBKAC LBBKDWB LBBBD

12

LJKBBLL LJKBCKL LJKCBCC

13

LJKCC LJKGK LJKJACC LJKJARC

14

LJKKD LJKKB LKKCC LKPFB

15

LUB UBB UCD UEJ UFI UGJ UGRBCB

16

QJHA QLAC QLACKA QLNOAA QLRBBB QRBB QHLLAALAB QLCCC QJUG

17

SLAA SLABB SLBAAS SLMAA SLMAAA SLMAFAFLAPF SLMAALBB

18

LATA LSTKATA LSTKBCBT LSTOTCBT LSTG LANTJ

19

LABCTKOAJBKOBRAJ LCBAKOCBRJKBKOBRAJARJN LDEPCPTKOBREJBKORJKBORJARJ:

20

MLLRAAVY MRAAAVAY MRAAVAY MRAAVAY MRAAVAY MRAAVAY MRAAVAY MRAAVAY MRAAVAY MRAAVAY

21

MNMBRBBMNNBNNDRNNDDNN BNNBNNBNNBNNBNN BNNBNNBNNBNNBNN BNNBNNBNNBNNBNN BNNBNNBNNBNNBNN

22

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