MEMORANDUM

Bendix Computer • DIVISION OF BENDIX AVIATION CORPORATION

TO: J. R. Campbell FROM: M. S. Thomson

SUBJECT: G-15 ECO's -- Logical Explanation DATE: February 16, 1960

Attached is a summary of the changes imposed upon the G-15's as a result of ECO's 970-1053.

This same material is covered in Norman Love's 1/7/60 memo to you, which documented what had been done to the hardware. This supplementary summary attempts to explain the logical reasoning behind the changes as follows:

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1.	TYPE-OUT AR, NUMERIC	L_2	N	0	8	31	<A>•<SA>
2.	TYPE-OUT AR, ALPHA	L_2	N	4	8	31	
3.	TYPE-OUT 19, NUMERIC	L_2	N	0	9	31	
4.	TYPE-OUT 19, ALPHA	L_2	N	4	9	31	
5.	TYPE-IN, NUMERIC:	L_2	N	0	12	31	<Q>•<SA>
	STOP NUMERIC TYPE-IN						<S>
6.	TYPE-IN, ALPHA:	L_5	N	4	12	31	<E>•<SA>
	STOP ALPHA TYPE-IN						
	(a) with terminal NORMALIZE M23, RELOAD, & CLEAR M23						<S>•<$\overline{SA}$>
	(b) without terminal NORMALIZE M23, RELOAD, & CLEAR M23						<S>•<SA>
7.	READ PR-2, STANDARD	L_2	N	1	12	31	
8.	READ PR-2, AUTO-RELOAD	L_5	N	5	12	31	
9.	PHOTO READ, STANDARD	L_2	N	0	15	31	<P>•<SA>
10.	PHOTO READ, AUTO-RELOAD	L_5	N	5	15	31	

1. AS_s

   (a) $DS \circ \overline{CV} \circ C1$

   (b) $\langle E\rangle \circ \langle SA\rangle \circ TO$

2. AS_r

   (a) $DS \circ \overline{CV} \circ \overline{C1}$

   (b) $\langle Q\rangle \circ \langle SA\rangle + \langle P\rangle \circ \langle SA\rangle +$ AUTO TAPE START

3. AUTO

   (a) $\text{SLOW IN} \circ AS$

4. OH_s

   (a) $DS \circ \overline{CV} \circ C1 \circ IN \circ$ 4

   (b) $\langle E\rangle \circ \langle SA\rangle$

   (c) $TYPE \circ OY \circ TO$

5. OH_r

   (a) READY

   (b) $TYPE \circ \overline{OY} \circ TO$

6. OY_s

   (a) $DS \circ \overline{CV} \circ C1 \circ AUTO \circ TF$

   (b) $\langle E\rangle \circ \langle SA\rangle \circ TO$

   (c) $AUTO \circ OG \circ TF \circ \overline{OF3} \circ OA3$

   (d) $AUTO \circ OG \circ TF \circ OF3 \circ M23$

   (e) $[STOP+REL]_{OB} \cdot S \cdot \overline{AS}$ replaces $[STOP+REL]_{OB} \cdot S$

   (f) $\text{SLOW OUT} \cdot \overline{HC} \circ \overline{OS} \circ TO$ replaces $\text{SLOW OUT} \cdot \overline{HC} \circ G$

7. OY_r

   (a) $TYPE \circ OH \circ OY \circ TO$

   (b) $TYPE \circ AS \circ \overline{OH} \circ \langle F-B\rangle$

   $\left.\right\}$ replace $TYPE \cdot F$

8. HC

   (a) $TYPE \cdot OY$

   (b) $TYPE \circ AS \circ OH$

   $\left.\right\}$ replace $TYPE \circ \overline{OC2} \circ \overline{OF3}$

9. OE_s

   (a) $\text{SLOW OUT} \cdot OY \circ G \circ \overline{OH}$ replaces $\text{SLOW OUT} \cdot OY \circ G$

   (b) $\text{SLOW OUT} \circ AS \circ OH \circ \overline{OY} \circ TO$

   (c) $\text{FAST OUT} \circ OD \circ G \circ \overline{AS}$ replaces $\text{FAST OUT} \cdot OD \circ G$

10. $M23_w$

   (a) $AUTO \circ OY \cdot TE \circ \overline{CF} \circ \overline{OG}$

   (b) $IN \circ OG \cdot OF3 \cdot OA1 \circ \overline{OH}$ replaces $IN \circ OG \circ OF3 \cdot OA1$

   (c) $\overline{OC4} + \overline{OC3} + \overline{AS} + \overline{OY} \circ \text{SLOW IN}$, which is equivalent to $\overline{AUTO \circ OY}$, now qualifies M23 recirculation

11. OD_s

(a) $AUTO \circ OG \circ TF \circ \overline{OF3} \circ OA3$

(b) $AUTO \circ OG \circ TF \circ OF3 \circ M23$

(c) $[STOP+REL]_{OB} \circ S \circ \overline{AS}$ replaces $[STOP+REL]_{OB} \circ S$

(d) $M \circ AS \circ OH \circ \overline{OA1}$

(e) $DS \circ SO \circ C8$

(f) $DS \circ SO \circ C7$

$\left.\begin{array}{l} \text{(e)} \\ \text{(f)} \end{array}\right\}$ replace $DS \circ SO \circ U$

12. OD_r

(a) $AS \circ \overline{OC4} \circ \overline{HC} \circ TO$

13. $OA1_s$

(a) $AUTO \circ OY \circ TE \circ \overline{CF} \circ OG$

(b) $M23 \circ O \circ \overline{OY}$ replaces $M23 \circ O$

14. $OA1_r$

(a) $AUTO \circ OY \circ T2$

(b) $\overline{M23} \circ O \circ \overline{OY}$ replaces $\overline{M23} \circ O$

15. OS_s

(a) $DS \circ S2 \circ SV$

(b) $AUTO \circ \langle S \rangle$

16. OG_s

(a) $AUTO \circ OH \circ OS \circ \overline{OG} \circ TF$

17. $OF3_s$

(a) $AUTO \circ OG \circ TF \circ \overline{OF3} \circ OA3 \circ OH \circ OS$

(b) $TYPE \circ OY \circ G$ has been removed

18. OC_r

(a) $SLOW\ IN \circ [STOP]_{OB} \circ \overline{OF2} \circ \overline{OD} \circ \overline{OG}$ replaces
$SLOW\ IN \circ [STOP]_{OB} \circ \overline{OF1} \circ OE$

(b) $\langle S \rangle \circ \overline{OC2} \circ \overline{OC1} \circ \overline{OH}$ replaces $\langle S \rangle \circ \overline{OC2} \circ \overline{OC1}$

(c) $IN \circ AS \circ OH \circ OF3 \circ F$

(d) $M \circ AS \circ OH \circ \overline{OA1}$

19. Q

(a) $SLOW\ OUT \circ OG \circ \overline{AS}$ replaces $SLOW\ OUT \circ OG$

20. TYPE PULSE & CARD PUNCH PULSE are both additionally qualified by $\overline{OH}$

21. The Levels $\longrightarrow$ OB's loading signal is now:

$OF1 \circ IN \circ \overline{OH} + OF1 \circ IN \circ \overline{OS}$ instead of $OF1 \circ IN$

22. The OB5 $\longrightarrow$ 5th level driver is now:

$OB5 \cdot \overline{AS} + OB5 \cdot AS \cdot OH \cdot \overline{OY}$ instead of OB5

23. $OC4_s, \; OC3_s \; = \; \langle E \rangle \cdot \langle SA \rangle \cdot TO$

$$\left.\begin{array}{ll} \text{24. PR-2 START THYRATRON} & = \; DS \cdot \overline{CV} \cdot \text{SLOW IN} \cdot \overline{OC1} \cdot 1 \\ \text{25. PR-2 STOP THYRATRON} & = \; \overline{\text{SLOW IN}} + [\text{STOP}]_{\text{TAPE}} \end{array}\right\} \text{effective equations formed in PR-2}$$

Note: Other equations, not relating to the IN/OUT system are mentioned in sec. E.

GENERAL Section A

A-1 The material to follow attempts to explain the logical alterations to the G-15 resulting from ECO's 970-1053. All changes outlined are present in machines starting with Serial #241. The hardware changes are indicated in the 1/7/60 memo from Norman Love to J. R. Campbell on the subject: "G-15 ECO's".

A-2 The primary purpose of the alterations is to adapt the computer to the PR-2 and ALPHA-NUMERIC TYPEWRITER, hence the changes are mostly restricted to the SLOW IN and SLOW OUT circuits. A few minor changes to other logical sections of the computer are also included in these ECO's.(see sec. E).

A-3 It is assumed that the reader is already familiar with the PR-2 and ALPHA-NUMERIC TYPEWRITER units themselves and is only concerned with the changes to the internal logic of the G-15.

A-4 Page 1 of this outline indicates the new IN/OUT operations available. Pages 2-4 list the equations which make these features possible. All equations are new and are added to pre-existing ones except where noted. The remainder of the outline will attempt to explain the logical activity in terms of the equations, to which reference will be made by number (e.g: "eq. 2a" means $AS_r = DS \cdot \overline{CV} \cdot \overline{C1}$).

A-5 Two new flip-flops have been installed for the purpose of establishing special IN/OUT modes. They are AS and OH. Their functions vary depending upon whether the operation is an INPUT or an OUTPUT as follows:

SLOW IN$\cdot\overline{AS}\cdot\overline{OH}$ -- normal input

SLOW IN$\cdot$AS$\cdot\overline{OH}$ -- input with AUTOMATIC RELOAD (PR-2)

SLOW IN$\cdot$AS$\cdot$OH -- input with AUTOMATIC RELOAD and terminal NORMALIZE M23 (ALPHA TYPE-IN)

SLOW OUT$\cdot\overline{AS}$ -- normal output

SLOW OUT$\cdot$AS -- ALPHA TYPE-OUT

Equations 1a, 1b, 2a, 2b, 4a, 4b, and 5a will appropriately set up as AS and OH prior to an IN/OUT operation.

AUTOMATIC RELOAD (SLOW IN·AS) Section B

(Refer to Dwg. #48, G-15 TECHNICAL MANUAL, REVISION #1)

B-1 This feature is needed to accommodate input entries which are not appropriately edited by RELOAD codes. Such non-standard entries may originate in the PR-2 accessory or the ALPHA-NUMERIC TYPEWRITER when operated in the ALPHA mode.

B-2 The AUTOMATIC RELOAD feature operates as follows: When M23 has acquired 116 bits of entry, an automatic RELOAD operation is initiated (i.e. M23 $\longrightarrow$ MZ, MZ $\longleftrightarrow$ M19).

B-3 The system employed to count the number of bits entered into M23 resembles the MARKER-BIT scheme used in FAST OUT. Assume that a tape is on the PR-2 with an entry of 58 HEX characters followed by a STOP code. Below is a blow-by-blow description of the activity in the SLOW IN system resulting from the new hardware, documented in terms of the equations on pages 2-4.

B-4 The L_5 N 5 12 31 command will set the OC's to the 1100 configuration (SLOW IN) by virtue of existing hardware. It will also set the AS (AUTOMATIC/STANDARD) flip-flop (eq. 1a) resulting in the AUTO term (eq. 3a), which qualifies the AUTOMATIC RELOAD control hardware. Eq. 6a sets OY by the TF pulse passed during the four word times of TRANSFER.

B-5 OY remains up for four word times, synchronized on TF's, for the purpose of establishing the initial contents of M23 before the first code arrives from the PR-2. The desired contents consist of zeros in all bit locations except T1 of word 0; the latter will contain a "1", henceforth known as the MARKER BIT. While OY is up, eq. 10c clears M23, and eq. 10a writes the "1" in T1 of word 0. (TE·$\overline{CF}$ is T1 of word times $\cong$ 0 mod. 4; $\overline{OG}$ will normally be high, but will defeat the MARKER BIT insertion in a special case indicated in sec. B-9.)

B-6 Eq. 24 starts the PR-2. (The hardware forming the combination is located in the PR-2 itself; DS·$\overline{CV}$, SLOW IN, $\overline{OC1}$, and 1 are individually transmitted from the G-15 to the PR-2.) The HEX codes will arrive from the PR-2 at a rate of approximately 400 per second (i.e. roughly 1 code every eight word-times). Each HEX character will call for a 4-bit precession involving the OA's and M23 by virtue of existing hardware. After each of the first 28 precessions the OA's will contain zeros since zeros were initially established in the high end of M23 (Sec. B-5). However, at TF time of the 29th precession, the MARKER BIT will appear in OA3, where it will be detected by eqs. 6c and 11a which set OY and OD causing a RELOAD immediately after the precession.

B-7 If a RELOAD code had been on the tape it would not have caused a RELOAD on account of the $\overline{AS}$ term applied to eqs. 6e and 11c. In the AUTOMATIC mode RELOAD operations will only be a function of the MARKER BIT.

B-8 During the M23 $\longrightarrow$ MZ operation of the RELOAD (OY time), M23's contents are set up as outlined in sec. B-5 to prepare for the next 116 bits of entry.

B-9 "RAPID" CASE: Since the PR-2 provides codes at a relatively rapid rate, it is possible that consecutive TF's can become E's. It is therefore possible that during the four word-times following the 29th precession, another precession could occur, identified by concurrence of OY and OG. This means that at the time the MARKER BIT is to be inserted an OA's $\longleftrightarrow$ M23 should be taking place. The effect needed in this case is this:

(1) Allow the new HEX code in the OA's to occupy T1-T4 of M23.

(2) Write the MARKER BIT in T5 instead of T1.

(3) Clear the rest of M23.

Item (1) is accomplished by existing hardware. The MARKER BIT is kept out of T1 by the $\overline{OG}$ term applied to eq. 10a. Item (2) is accomplished by setting OA1 at T1 of the 0 mod. 4 word time (eq. 13a). In effect this places a "1" to the left of the 2^3 bit of the HEX code. Item (3) is accomplished by resetting OA1 at T2 time (eq. 14a) and by applying $\overline{OY}$ to the M23 $\longrightarrow$ OA1 gates (eqs. 13b and 14b).

B-10 After the second group of 29 HEX characters is entered another RELOAD will take place by virtue of the same hardware just discussed.

B-11 The entry example being used consists of 58 HEX characters followed by a STOP code; therefore the STOP code will follow the second RELOAD operation. In the AUTOMATIC mode, STOP codes will not perform the RELOAD function (eqs. 6e and 11c), As usual the STOP code is locked in the OB's until OC_r.

B-12 Eq. 18a provides an OC_r term compatible with the AUTOMATIC and STANDARD modes of input. In the example being traced, the STOP code will arrive <u>during</u> the RELOAD operation. OD will be high until the RELOAD is concluded. Upon conclusion, $\overline{OD}$ will permit OC_r.

B-13 Had a RELOAD not been in process at the time the STOP code arrived, OC_r would have occurred as soon as OF2 reset (since OD would have been down). This case can occur when entries do not consist of an integral number of 4-word groups.

B-14 In the STANDARD input mode, OF2 will prevent OC_r until after (E) has set OD and OY. OD and OY will perform the standard RELOAD function; OD will prevent OC_r until RELOAD is concluded. In the old scheme, OE caused OC_r one drum cycle before OD reset. This was for the purpose of stopping the regular photo-reader mechanism as early as possible. In the new scheme the stop is delayed one drum cycle, resulting in approximately 6/10 inch of extra tape travel after the STOP code is read.

B-15 The PR-2 stops itself immediately after reading a STOP code by virtue of internal hardware indicated by eq. 25. (SLOW IN is inverted in the PR-2 and is used in lieu of READY; $[\text{STOP}]_{\text{TAPE}}$ is decoded by a "matrix board" in the PR-2.)

B-16 Additional MARKER BIT detection hardware, indicated by eqs. 6d and 11b, is required to accommodate entries employing TABS and CR's which involve 1-bit precessions. If, for instance, 115 bits of entry are in M23 and a CR code arrives, the MARKER BIT will not appear in OA3 at TF•OG time as in the 4-bit precession case. It will, however, be in M23 at that time and can be interrogated there.

ALPHA TYPE-IN (SLOW IN•AS•OH) Section C

C-1 An ALPHA TYPE-IN may be initiated either by a command or by the E key as indicated on page 2. The AS flip-flop is set (eq. 1a or 1b), enabling the AUTOMATIC RELOAD system. If the E key is used to enable ALPHA TYPE-IN, eq. 23 sets the OC's to 1100, and eq. 6b sets OY (to clear M23 and insert the MARKER BIT).

C-2 Eq. 4a or 4b will set OH. OH allows the S key, which terminates the input, to perform special functions prior to resetting the OC's. These functions are as follows:

1. Normalize M23
2. Reload
3. Clear M23

C-3 AS is sent to the ANC-1 coupler, where it turns on the ALPHA encoding circuits and turns off the NUMERIC encoding circuits with the result that when a typewriter key is struck, two consecutive 5-level codes will enter the SLOW IN system. The codes will all have a "1" in 5th level, hence will be interpreted as "DIGITS" and will each enter four information bits into M23. When a key is struck, a total of 8 bits will be precessed into M23 -- 4 bits at a time.

C-4 It is interesting to note that M23 can hold $14\frac{1}{2}$ ALPHA codes. Therefore, when the 15th ALPHA code is entered, the first 4 bits cause the automatic RELOAD while the second 4 bits will follow the RELOAD. As a result, the first 4 bits will be in T1-T4 of M19.00, while the second 4 bits will be in T1-T4 of M23.00. Eventually the 8 bits will be rejoined in M19 either by virtue of the next automatic RELOAD or by virtue of operation of the (S) key.

C-5 When the (S) key is struck M23 will be normalized and an automatic RELOAD will take place after normalization. This assures that the final information in M19 will be "compacted", which means there will be no blank space between ALPHA codes or between the two halves of an ALPHA code.

C-6 Since ALPHA input involves no MINUS SIGNS (00001), TABS (00011), or CR's (00010), the OS flip-flop is available to be borrowed to control the automatic normalize M23 function.

C-7 When the (S) key is struck, eq. 15b sets OS. Then eq. 16a in conjunction with OG's normal reset term causes OG to alternate -- up for 4 word-times, then down for 4 word-times. Note that AUTO·OH qualifies this activity, meaning it is peculiar to ALPHA TYPE-IN only.

C-8 Every time OG cycles, M23 precesses 4 bits to the left while zeros are inserted in the right. When the MARKER BIT reaches OA3 it is detected by eqs. 6c and 11a calling for a RELOAD. The MARKER BIT reaching OA3 means that M23 has been normalized, hence the process succeeded in normalizing M23 then RELOADING.

C-9 Even after the RELOAD is initiated, OG will continue to cycle. This is used to advantage in clearing M23. When the MARKER BIT was detected and the RELOAD was initiated, OY cleared M23 while eq. 10a inserted the MARKER BIT in T1 of the 0 mod. 4 word of M23. It is now necessary to clear M23 of the MARKER BIT.

C-10 At the time this final RELOAD was started, eq. 17a set OF3. This established the OA1 $\longleftrightarrow$ M23 precession path. The next time OG rises the writing term for M23 will be eq. 10b. Note that $\overline{OH}$ qualifies this term, and since OH is high during ALPHA TYPE-IN, nothing can be written during the precession. Hence M23 will be cleared of the MARKER BIT and its terminal contents will be all zeros.

C-11 When the RELOAD concludes at F time, the OC's will be reset by eq. 18c. The $\overline{OH}$ term applied to eq. 18b prevents the S key from resetting the OC's immediately. (If the ENABLE switch had been on when S was struck, the OC's would have been reset immediately and there would have been no normalize M23 -- RELOAD -- clear M23 sequence.)

C-12 The set-up term for the OB's, previously OF1•IN, had to be further qualified by $\overline{OH \cdot OS}$ (eq. 21). Due to the encoding circuit structure in the ANC-1, the S key will cause the generation of a 11000 code followed by a 10000 code. These must be kept out of the OB's, otherwise they would initiate "DIGIT" insertion activity which would conflict with the terminal normalize M23 operation. $\overline{OH \cdot OS}$ will be rendered low by the leading edge of the <S> signal and will prevent OB loading before the codes arrive on the level lines.

ALPHA TYPE-OUT (SLOW OUT·AS) Section D

(Refer to Dwg. #52, G-15 TECHNICAL MANUAL, REVISION #1)

D-1 The SLOW OUT system has been modified to accommodate a new form of data extraction involving the extraction of two consecutive 5-bit codes with a single TYPE pulse accompanying the second code of the pair. In effect, a 10-bit code is sent to the ANC-1 where it will be appropriately decoded. ALPHA TYPE-OUTS may be initiated by the commands indicated on page 1. The command sets AS (eq. 1a), which establishes the ALPHA output mode by qualifying some circuits and disqualifying others both in the G-15 and in the ANC-1.

D-2 In the absence of feedback, each ALPHA character cycle involves 4 drum cycles:

#1	$OY \cdot \overline{OH} \cdot \overline{OE}$:	(send TYPE pulse for previous character to ANC-1)
#2	$OY \cdot OH \cdot OE$:	M19 $\longleftrightarrow$ OA's -- 1st extraction
#3	$\overline{OY} \cdot OH \cdot \overline{OE}$:	1st extraction code in OB's
#4	$\overline{OY} \cdot \overline{OH} \cdot OE$:	M19 $\longleftrightarrow$ OA's -- 2nd extraction
(#5	$\overline{OY} \cdot \overline{OH} \cdot \overline{OE}$:	kill time in case of feedback)
#1	$OY \cdot \overline{OH} \cdot \overline{OE}$:	2nd extraction code in OB's; send TYPE pulse to ANC-1

In the event that feedback is present at the end of the #4 state, the system will not advance to the #1 state, but will idle in the #5 state, delaying the TYPE pulse when necessary. (A confusion factor exists, as it did in the old SLOW OUT system, in that the timing cycle is out of phase with the logic cycle. That is, the timing cycle -- in terms of drum cycles -- is 1-2-3-4-(5), whereas the logic cycle is 2-3-4-(5)-1. Therefore the sequence above includes two #1 drum cycles. In terms of hardware justification, the cycle will be considered to begin with the #1 drum cycle.)

D-3 In the ALPHA mode, OY and OH may be thought of in terms of a counter having four states. The relaxed state is $\overline{OY} \cdot \overline{OH}$ (#4 or #5). Feedback permitting, OY will be set by a TO, yielding $OY \cdot \overline{OH}$ (eq. 6f), establishing the #1 state. In the ALPHA mode, $\overline{HC}$ (inverse of eqs. 8a and 8b) reduces to $\overline{OY} \cdot \overline{OH}$. In effect, OY_s = SLOW OUT$\cdot \overline{OY} \cdot \overline{OH} \cdot$TO$\cdot$(OT), meaning the #1 state can be established only from the #4 or #5 state. Typewriter feedback prevents OY_s by raising HC. (The $\overline{QS}$ term in eq. 6f will be discussed in sec. D-15.)

D-4 The #2 state will be established by setting OH with the following TO (eq. 4c), establishing OY∘OH. The next TO resets OY (eq. 7a), establishing $\overline{OY}$∘OH, the #3 state. Then the next TO resets OH (eq. 5b), giving $\overline{OY}$∘$\overline{OH}$, the #4 state. The #5 state is the same as #4 as far as OY and OH are concerned; OE is the discriminating factor. Note that the previous control of OY in the unmodified G-15's has been removed (eqs. 6f, 7a, 7b, 8a, 8b, 17b).

D-5 During the #2 and #4 states, OE is high by virtue of eqs. 9a and 9b which set it at the ends of the #1 and #3 states. OE causes M19 ⟷ OA's precessions (or AR ⟷ OA's precessions in cases of AR TYPE-OUTS). Regardless of the contents of the FORMAT lines, the SLOW-OUT system will follow an all-DIGIT format. This is accomplished by qualifying Q by $\overline{AS}$ (eq. 19a), which keeps the OF's cleared. (OF's = 000 constitutes the DIGIT configuration.)

D-6 After each precession M transfers the contents of the OA's to the OB's. OB5 will contain a "1" starting with the first code inserted in the OB's, and will continue to contain a "1" until READY is set. This is a function of pre-existing OB5 control hardware and ties in with the zero-suppression system. (The first extraction of the first ALPHA code will be in the form 1xxx in the OA's, hence will set OB5 at M time.)

D-7 The OB's will control the five level-relays in the ANC-1 by means of the puller tubes in the LOGIC CHASSIS. 5th level, however requires special treatment. The ANC-1 requires its codes in the following form:

1st extraction:	1 1 a b c
2nd extraction:	0 d e f g

Bits b c d e f g determine which key solenoid will be energized, while bit a controls "CARRIAGE" SHIFT (up-down). 5th level must be a "1" in the first extraction and a "0" in the second and is used as an extraction identifier.

Since OB5 will constantly contain a "1" starting with the #3 state of the first character obtaining cycle, the wire connecting OB5 to its relay puller tube is intercepted as indicated in eq. 22. In the ALPHA mode $\overline{OY}\cdot OH$ will allow 5th level to energize the 5th relay in the ANC-1 only during the #3 drum cycle when the 1st extraction should be in the OB's and the level relays. During all other states it is blocked, complying with the requirements of the ANC-1.

D-8 The TYPE pulse is generated during the #1 state ($OY\cdot\overline{OH}\cdot\overline{OE}$) -- note eq. 20. The maximum rate at which TYPE pulses will be sent to the typewriter will be one every 4 drum cycles (i.e. slightly over 8 characters per second). Feedback will normally not reduce this rate except in the cases of TAB, CR, and "CARRIAGE" SHIFT (up-down). These functions will stop the timing circuits in the #5 state when necessary, preventing delivery of the next TYPE pulse and the initiation of the next character-obtaining cycle.

D-9 There is one peculiar feedback case associated with certain special characters. These characters are all upper-case but are coded as lower-case characters. When such a character is detected in the ANC-1 at TYPE pulse time, it is necessary to:

1. Shift the carriage UP, and
2. Prevent the selected key solenoid from being energized until the carriage has shifted, and then
3. Send a second TYPE pulse to energize the key solenoid after the carriage has shifted.

The case is handled in the following fashion: $OY\cdot\overline{OH}$ (state #1) is set up, generating the TYPE pulse. When the TYPE pulse detects a special character, the <F-B> signal rises (as a function of K11B in the ANC-1). Eq. 7b causes OY to be reset, within a few milliseconds of the time it was set, backing the timing circuits up to the #5 state ($\overline{OY}\cdot\overline{OH}\cdot OE$) of the previous timing cycle, and cutting short the TYPE pulse. The portion of the TYPE pulse which was passed succeeds in causing the carriage up-shift (by pulling in K11A in the ANC-1) but did not energize a key solenoid (due to an intercept inserted by K11C and K11D in the ANC-1). While the "carriage" is shifting, <F-B> holds HC high preventing OY from being set again; however, when the carriage has finished its shift, <F-B> drops and the first TO will set OY, returning the timing circuits to the #1 state ($OY \cdot \overline{OH}$), and re-issuing the TYPE pulse, which will energize the key solenoid this time.

D-10 The ALPHA output system will continue to cycle until the output line (M19 or AR) is exhausted of compacted ALPHA characters. The top bit of each 8-bit character is always a "1" and will appear in OA1 after the 1st extraction (i.e. just after the #2 state). If during the first pulse period of state #3, there is a "0" in OA1, eq. 18d will detect it and reset the OC's, stopping all output activity. (This does not necessarily mean that M19 is clear as in the case of NUMERIC SLOW-OUT; it means that there was no ALPHA character in bits 22-29 of M19.107.)

D-11 The same equation also sets OD (eq. 11d) for the sole purpose of inhibiting the READY signal until typewriter feedback indicates the output operation is truly finished. When HC drops, eq. 12a resets OD raising the READY signal. ($\overline{OC4}$ applied to this equation prevents OD_r at the beginning of a TYPE-OUT; OC4 will be high until after the OC's have been reset by eq. 11d.)

D-12 In borrowing OD for the delay-READY function, it was necessary to qualify the OE_s term shown in eq. 9c by $\overline{AS}$. This prevents the FAST-OUT circuits from causing an M19 $\leftrightarrow$ MZ precession, a case which arises when OD is set and the OC's are reset. This would be particularly annoying in the case of ALPHA TYPE-OUT from AR.

D-13 Changes to NUMERIC TYPE-OUT resulted from the ALPHA modifications. Logically NUMERIC TYPE-OUT is the same as it was in the old system except for timing control. Unless feedback due to a TAB, CR, or SPACE operation holds HC up, the output cycle will consist of 3 drum cycles.

#1	$OY \cdot \overline{OH} \cdot \overline{OE}$	(send TYPE pulse for previous character to ANC-1)
#2	$OY \cdot OH \cdot OE$	M19 $\longleftrightarrow$ OA's (only extraction)
#3	$\overline{OY} \cdot OH \cdot \overline{OE}$	code placed in OB's
(#4	$\overline{OY} \cdot \overline{OH} \cdot \overline{OE}$	kill time in case of feedback)
#1	$OY \cdot \overline{OH} \cdot \overline{OE}$	send TYPE pulse to ANC-1 for code just obtained

In the NUMERIC mode, advancement from state #1 to #2 to #3 will progress as it did in the ALPHA case; however, OE will not be set at the end of state #3 since AS is low and eq. 9b will be disqualified. Furthermore eq. 8b will not raise HC, hence the state of OH does not condition OY_s and state #1 can directly follow state #3 unless feedback results in state #4. (State #4 in the NUMERIC mode is equivalent to #5 in the ALPHA mode. The ALPHA state #4 configuration, $\overline{OY} \cdot \overline{OH} \cdot OE$, is avoided.)

D-14 There is no feedback from the typewriter for any of the character keys, hence they will be energized at a rate of 1 every 3 drum cycles (i.e. better than 11 characters per second).

D-15 The delay circuit, involving OF3, which slowed the old SLOW OUT system to 8 characters per second has been removed (note eqs. 8a, 8b and 17b). This created a problem in that it resulted in one less drum cycle delay before the first M19 $\longleftrightarrow$ OA's precession of a NUMERIC TYPE-OUT M19. This rendered the new SLOW OUT system incompatible with INTERCOM 1000, which depended upon the delay. The easiest solution was re-insertion of the delay to maintain compatibility. OS was borrowed for this purpose. The TYPE 19 command (0 9 31) sets OS by eq. 15a. OS will remain high until after the first TO, then M will reset it. $\overline{OS}$ applied to eq. 6f delays the setting of OY for one drum cycle. Using OS for this purpose at this time does not conflict with its SIGN handling function.

MISCELLANEOUS — Section E

E-1 SET READY command and OD_s

Equations 11e and 11f reduce to the following:

$$DS \cdot SO \cdot (C8 + C7) \quad \text{replaces}$$

$$DS \cdot SO \cdot (OC2 + OC1) \quad \text{as the OD set term}$$

The original purpose of DS•SO• U was to cause OD to be set at the time of TRANSFER when a 1, 2, or 3 $\rightarrow$ 31 command initiated a FAST OUT operation. Setting OD causes an M19 $\leftrightarrow$ MZ precession when the FAST OUT signal is high. This is required at the beginning of a MAG TAPE WRITE or a FAST PUNCH operation. Unfortunately the DS•SO• U term will set OD in the event that a SET READY command terminates an IN/OUT operation in which the OC configuration is not congruent to o mod. 4. This means that when a SET READY command stops any IN/OUT operation other than MAG TAPE SEARCH REVERSE, TYPE AR, or TYPE-IN, there will be an M19 $\leftrightarrow$ MZ precession and a delay in the READY signal until the unwanted precession is concluded. The new OD_s equation relieves the problem.

E-2 Additional F and P key functions

When the F key or the P key is activated (with ENABLE on), the "NEXT COMMAND FROM AR" flip-flop (CG) and the "TEST" flip-flop (CQ) will be reset while the "HALT" flip-flop (CH) will be set. <F>•<SA>•WORD 107 + TAPE START•WORD 107 has been added to CG_r, CQ_r, and CH_s for this purpose. (TAPE START = <P>•<SA> +AUTO TAPE START.) Note: Due to a change in assignment of TRUE-FALSE nomenclature applied to CH, CH_s mentioned here means CH_r on Dwg 30 of the TECHNICAL MANUAL.

E-3 Changes to Accommodate the CA-2

The following signals are sent to the CA-2 for control purposes:

(a) TO

(b) T21•CN

(c) DS•S4•SX (i.e. 19 $\rightarrow$ 31)

(d) DS∘S5∘SW (i.e. 22 ⟶ 31)

(e) 4, (f) 1, (g) 2, (h) 3, (i) C1

(Note: The DA-1, which uses the same connector as the CA-2, now internally forms the DS∘S4∘SX∘ 4 (start) and DS∘S4∘SX∘ 1 (stop) combinations by using the items listed under c, e, and f above. These combinations were previously formed in the G-15.)

Additional terms, originating in the CA-2, are applied to set the CQ (TEST) flip-flop in the G-15 to permit interrogation of certain states of the CA-2 by the 22 ⟶ 31 command.

E-4 Plotter Accessory

Accommodations have been made for the G-15 to directly control a plotter accessory. Hardware is installed to send the following terms to the plotter:

-dx:	DS∘S4∘SV∘ 2	(2 17 31)
+dx:	DS∘S4∘SV∘ 3	(3 17 31)
-dy:	DS∘S4∘SW∘ 2	(2 18 31)
+dy:	DS∘S4∘SW∘ 3	(3 18 31)

The old 18 ⟶ 31 command, which sent M20∘ID to the OUTPUT REGISTER, must now be written with a CHARACTERISTIC of "0" since the controlling terms are now qualified by 4 as follows:

DS∘S4∘SW∘ 4 ∘PJ∘M20 (data)

DS∘S4∘SW∘ 4 ∘PJ∘WP (control)