# HARDWARE

# TELETYPE PROGRAM ENTRY

Programs may be entered into the Carnegie Tech G-21 system from specially modified remote stations located in Scaife Hall and other department buildings. With authorization from the center, standard 33 or 35 teletypes connected to the DATA-PHONE or TWX Prime networks may be used. A standard teletype on the regular telephone network may be authorized to use the Carnegie Tech computer.

Teletype program entry may be described as a conversation between a man and the computer. The conversation takes place in three phases: input, wait, output, and is initiated by establishing a telephone connection between a teletype and the computer. If the computer elects to receive input, it will so indicate and the input phase goes into effect. The user then types the text of the program in response to line numbers supplied by the computer, each line becoming the image of one punched card.

The wait phase begins when the entire text has been entered, and the user types a termination signal. This continues while the program is waiting its turn to be run and while it is being executed by the computer. At the completion of program execution, the conversation enters the output phase; any output which the program designated to be printed on the teletype is now printed. (The program may also produce output on the line-printer of the G-21 computer.)

In the output phase, the conversation is entirely one-sided; the only thing the user can do during this phase is press the BREAK button or disconnect the teletype, either of which terminates the conversation. When the computer completes the output, the conversation has come to an end.

Since the user will not generally wish to retype the entire program for each run, he will find the AND system useful. AND maintains files of user's card images in the computer's bulk memory and provides a simple language for fetching and editing these images.

Certain teletypes are equipped with a paper tape punch and reader which may be used to create paper tape copies of programs as a protection against hardware failures which necessitate retyping.

USE OF STANDARD TELETYPES

    Certain characters appear in different positions on the standard
teletype keyboard than on the modified Carnegie Tech teletypes.  The user
should believe the labelling of the keys and not try to compensate for
their different locations.  The following table defines the translitera-
tion which is used for those characters of the G-21 alphabet which do not
appear on the standard teletype keyboard:

| G-21 | Standard Keyboard |
|------|-------------------|
| $\vert$ | $!$ |
| $\rightarrow$ | |
| $\neg$ | ? |
| 10 | @ |
| $\vee$ | % |
| $\neq$ | \ |
| $\wedge$ | & |
| $\downarrow$ | " |

    The effect of the TAB key is obtained on the standard teletype
by typing CTRL-I (labelled  TAB ) or by using LINE FEED.

    Except as a substitute for TAB, the LINE FEED key need never be
typed; LINE FEED will be automatically sent by the computer when appropriate.

    There is unfortunately no visible analog to the KEYBOARD SEND
light.  Any characters typed when this light would be off (if there were
one) will be invisible to the computer.


KEYBOARD SEND LIGHT

    The yellow KEYBOARD SEND light is located to the left of the keyboard.
When lit, it indicates that the user may type information to the computer.
When the teletype is connected to the computer, the keyboard is electrical-
ly disconnected except when this light is on.

KEYBOARD

The keyboard contains the 64 characters of the G-21 alphabet except that instead of the $\neq$; the \ appears. Certain keys are labeled with two different characters; the lower character is produced when such a key is struck alone; the upper character is produced by holding down either SHIFT key while the key is struck.

Certain keys may be used in conjunction with the CTRL (control) key which is used like the SHIFT key to control the operation of the teletype or to send control information to the computer. Such a control character will not be printed but will become part of the text being input.

The character \ is interpreted as "backspace" and may be used to correct typing errors discovered before a line is completed. By means of a command to the computer some other characters may be specified to be the backspace character in which case the \ will be interpreted as $\neq$.

The end of each line of input, including the job card, control lines (commands to the computer), and program card images, is signalled by the RETURN key. The KEYBOARD SEND light will then go out and the keyboard will be disconnected until the computer is ready to accept the next input line. The computer will then type the next line number and turn on the KEYBOARD SEND light again.

The red LOC CR (local carriage return) key returns the teletype printer carriage without signalling the end of the current card image and without upspacing the paper.

The red LOC LF (local line feed) key rapidly unspaces the paper as long as it is held down.

If the red REPT (repeat) key is held down and any character is typed, that character will be repeated until the REPT key is released.

The ALT-MODE key has no use in our system.
The RUB-OUT key and the red LOC BSP key have to do with the paper tape punch and will be explained later.

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PROGRAM ENTRY PROCEDURE

If the computer is willing to accept input from teletypes, after a
connection is established it will type a message of the form:

a OPER bbb cc ccc cc d

ee:ee:ee BEGIN

'a', which may be blank, indicates the current mode of computer operation
and which central processor is in connection with the teletype. 'bbb' is
the user number of the current computer operator. 'cc ccc cc' is the
date. 'd' identifies the channel in use, i.e., to which of the computer's
16 incoming telephone lines this teletype is connected. 'ee:ee:ee' is the
time of day in hours, minutes, and seconds on a 24 hour clock. This is
followed by the line number '0' for the first input line, which must be
the image of the job card to be used for the run. The KEYBOARD SEND
light will come on indicating that the user may type.

If the computer is not willing to accept teletype input, it will
usually type out a message explaining why not and the phrase REMOTE NOT
IN OPERATION and then disconnect the teletype.

Sometimes the computer will be prepared at this point to accept
only control lines. In this case it will type: *$= instead of the
line number 0. The user may then type any of the control lines: OUTPUT,
TELL, or MESSAGE without typing the initial $=.

JOB CARD ENTRY

Columns 1 and 2 of the job card image must contain $$. If they do
not, the computer will ignore the line and ask for a correct job card by
typing the line number 0 again. The other fields of the job card are

column 5                        Option punch
column 6                        RA reservation
column 12                       User tape number

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| | |
|---|---|
| columns 20-23 = FIRST TAB | Maximum run time in minutes. This refers to actual program execution time and does not include the time taken for teletype input to the computer or for printing of output on the teletype. |
| columns 24-27 = SECOND TAB | Maximum number of pages of printed output. By requesting zero lines of printed output on the job card, one may suppress all line-printer output on the teletype. |
| columns 28-32 = THIRD TAB | System name. This will usually be AND for teletype initiated runs. |
| columns 33-40 = FOURTH TAB | Usage number. If the use of teletypes is currently restricted to the Computation Center staff members, the computer will not accept a job card without an appropriate usage number. The message ILLEGAL USAGE will be printed in this case. |
| columns 41-80 = FIFTH TAB | Name, department, extension, comments. |

END OF PROGRAM INPUT

Teletype input is limited to 209 lines including the job card in any one conversation. When all program and data cards have been typed in, the user types the line:

$$ <Carriage Return>

The computer will then type the time and the waiting and enter the wait phase of the conversation.

## WAIT PHASE

After the PROGRAM ACCEPTED has been typed out the user may type
control lines while waiting for the program to be executed. To do this,
the user presses the BREAK button. The computer will then output :$=
in place of a line number. The control line CANCEL may be typed without
the initial $= and the teletype will return to the waiting state. If
the program should complete execution while a control line is being
executed, the execution of the control line will be terminated and
printing of teletype output will begin.

## USE OF THE TAB KEY

The TAB key is interpreted as a skip to the next field of the
card image being typed, as determined by the language specified in
columns 1 and 2 (the language field). If the language field is blank,
the language specified by the last defined language field other than
"$=" will be used.

It should be realized that these column numbers refer only to
the card images within the computer; the actual spacing on the printed
teletype page will not generally correspond, since the same set of
fixed mechanical TAB stops must be used for all languages. (Thus, the
first TAB typed means column 4 if the language field is "TH" and column
20 if the language field is "$$"; in either case, however, the teletype
will tabulate to the same place.) On the model 33 teletype, the TAB
key does not cause visible spacing, although the effect on the card image
being created is the same. When usuing a model 33 teletype, one may
improve the printed copy by typing one or more spaces before each TAB.

Teletype TABs differ in a very important (and unexpected) way
from typewriter TABS or the keypunch SKIP key. If, for example, the
fourth TAB for a language is set to column 33, then the fourth TAB typed
will set the column-pointer to 33 even though the user may have already
passed that column. Thus, typed characters may be lost, and the user
is given no warning that this has taken place.

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Backspaces are processed after TABs have been expanded, so to retract an erroneous TAB, one must type one backspace for each card-column skipped over by the TAB.

RIGHT MARGIN OVERFLOW

The teletype carriage is physically 90 character positions wide on the model 35 teletype and 72 on the model 33. During the input phase, four of these positions are taken for the line number which the computer types. Since the card image being assembled consists of 80 columns, it may become necessary (because of having used several backspaces in the line, for example) to type beyond the physical right margin of the teletype. In this case, to keep a printed record of all input, one should use the red LOC CR key to return the carriage and the red LOC LF key to upspace the paper (don't hold it down very long!).

However, if 96 characters including TABs (counted as one character each), backspaces, and control characters are typed in an input line, the KEYBOARD SEND light will go out, forcing the end of that line. If this happens, the line may be retyped by using the SETTO command described later.

CONTROL LINES

The language field $= denotes a control line or command to the computer. A control line may be typed during the input phase in place of any ordinary input line, and also at certain other times described later.

Tabs and spaces are generally ignored in control lines, and backspaces are not recognized as such and therefore should not be used.

USER-SPECIFIED TAB INTERPRETATION

The use may define one language of his own, and prescribe the corresponding interpretation of TABs. The language field of each input line will be checked against the language field specified by the user and if they are the same, TABs will be interpreted according to the user's specifications; otherwise the standard language table will be used. The

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user specifies his language field and its corresponding set of TAB-columns by typing the control line:

$$\$= \text{TABS}; \{ \text{ language } \} \quad : C_1, C_2, \{\ldots\} C_8$$

The last two non-blank characters before the : are taken as the user's language field, and the integers $C_1$, $C_2$, ..., $C_8$ are taken as the card-columns to which the first 8 TABS are set the column pointer. Each $C_i$ must be an integer between 1 and 84. Any TABs typed after the eigth will be ignored. This special TAB interpretation will be in effect only for the duration of the input phase of the conversation during which it is defined.


OPERATOR MESSAGES

At any time during the conversation, the computer may type a message from the computer operator. The same message will appear on all teletypes which are connected to the computer.

ESTABLISHING A CONNECTION WITH THE COMPUTER

There are 16 lines into the computer, but only one number need ever be dialed. Calling this number will automatically hunt for the first computer line not in use. Since there are more than 16 teletype units, only 16 teletypes may be connected to the computer at any one time. If another tries to get the computer, it will receive a busy signal. During the input phase, if the user takes more than five minutes to complete any single input line, it is assumed that the teletype has been abandoned and the computer will cause the teletype to disconnect, so that someone else will have a chance to use the line.

ACTION: Push the ORIG button. INDICATION: The lamp under this button will light and the teletype motor will start. A dialtone will be heard from the speaker under the keyboard. (It may be necessary to adjust the SPKR VOL knob.)

ACTION: Insert the plastic dialing card into the card dialer slot and push it all the way down; then push the START bar. INDICATION: The card will slowly move out as the number is dialed. Ringing will be heard from the speaker followed by a tone indicating that someone has answered.

A message will then be typed from the computer, acknowledging the connection.

If all lines to the computer are in use, a busy signal will be heard instead of a ringing signal. In this case, release the connection as described below, and try again later.

If the computer is not prepared to handle teletypes, it will not answer an incoming call. If this condition is encountered, release the connection after a few minutes, and check with the Computation Center answering service or with the computer operators.

## RELEASING A CONNECTION WITH THE COMPUTER

ACTION: Press the CLR button. INDICATION: The ORIG light will go out and the CLR light will come on for a few seconds. When the connection has been cleared, all lights will go out and the teletype motor will go off.

## TERMINATING THE CONVERSATION

At any time during the wait phase, the control line CANCEL may be entered. If typed before program execution has begun, the program will not be run. If typed after the program execution has begun, the program will not be terminated.

While output is being printed, pressing the BREAK button, located to the left of the keyboard, or disconnecting the teletype will terminate the conversation. Printing of output on the teletype will cease, but all line-printer output will have been printed.

## RESTARTING THE CONVERSATION

When a conversation is ended, the computer may disconnect the teletype or it may enter the idle mode, in which case a new conversation may be initiated as follows:

At any time during the input phase or when the teletype is in the idle mode (after END of run time if the teletype is still connected to the computer), a new conversation may be initiated by pressing the BREAK button. The computer will respond as described above under the heading PROGRAM ENTRY PROCEDURE.

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ERROR CORRECTION PROCEDURES

Backspace. Any character may be designated to be the backspace charac-
ter by the control line: $= BACKSPACE: {character } The backspace charac-
ter is initially set to \ when a connection is established. Backspaces
are not recognized as such in control lines and should not be used there.
Backspaces are processed after TABs have been expanded, so to retract an
erroneous TAB, one must type one backspace for each card-column skipped
over by the TAB.

Discarding an incomplete line. If the user observes before he types
RETURN that he has made an error in a line, he may cause the computer to
ignore that line by typing CTRL-U (error) followed by RETURN. The computer
will then retype the same line number and the line may then be typed
correctly. The language field of the deleted card will be processed,
however, and that language will be used if the next card has an undefined
language field.

Replacing a line which has been typed in. The user may at any time
move the line-counter to a value which has been previously typed as a line
by the computer by typing the control line:

$= SETTO {line number}

The line-counter will be set to the given integer. (If the integer is
greater than the maximum line number typed out by the computer in this
conversation, the error message WHAT will be printed and the computer will
ignore the control line.)

Let us consider an example: Suppose a user has typed in line
successfully up to and including 18, when he observes errors on lines
5 and 6. On line 19, he would type:

$= SETTO 5

The computer will then type out the line number 5. (There is frequently a
little more delay in this process than in the usual step from one line
number to the next.) The user should then type in the corrected line 5.
The computer will then type the line number 6, and the user may type in
the corrected line 6. The computer will then type out the line number 7.

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The user should then set the line-counter back to 19 by typing:

$= SETTO 19

The computer will then type out 19 and the user may continue.

Recovering lines of the previous program. It is possible to set to a line number greater than the maximum line number typed so far. To do this, type:

$= SETTO {line number} *

(If the asterisk is not present, the error message WHAT will be printed and the computer will ignore the control line.) The result will be that those card images which were skipped will be filled in with the card images of the same number from the previous program entered from the same teletype. Thus it is possible to recover and rerun a program which has been clobbered. It is not always possible to recover everything which has been typed in -- only those lines which have been written onto the disk may be recovered. There are three times that typed-in card images are written onto the disc: when the terminating $$ is typed in; if the computer intentially forces a dis-connection; and when the input buffer fills up. This buffer has room for 7.62    card images. As a result, the first  7.62    card images are written onto the disc when RETURN is struck for line 7, and the next 7.62    images when line 15 is completed, etc. For example, if you have typed in a 20 line program, and after getting PROGRAM ACCEPTED, the remotes are clobbered, the program may be recovered by doing:

$= SETTO 20 *

and then typing a new $$.

If the remotes are clobbered while a program is being typed, for example after typing line 20 do:

$= SETTO 15 *

and retype portion of the program starting with line 15.

AND editing of a teletype input file. If more complicated editing of a completed teletype input file is desired, the TTYND system may be used. The full editing power of the AND language may be used on the text of the previous program entered from this teletype.

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RESTARTING THE OUTPUT PHASE

If the system goes down while teletype output is being printed, one may ask to have all one's teletype output printed out again by typing the control line:

$= OUTPUT

This may also be done if it is necessary to re-establish the connection with the computer.

DELAYS IN OPERATION

Occasionally the computer will take a long time to come back with a line number or other expected message. When this occurs, it is usually because the computer operator is experiencing some difficulty or there has been a hardware malfunction. If it is the former, the best thing the user can do is be patient. As soon as the operator is able to get things going again, the next line number will be typed out as usual. It is advisable that the user not press BREAK or turn off the teletype while he is waiting, since either one of these will usually result in terminating the conversation. If the delay gets too long (say about 5 minutes), it may be appropriate to call the Computation Center answering service or the computer operator to find out what the problem is.

On rare occasions, the monitor will be so badly clobbered that all teletype input is lost. In that case, a conspicuous message may be sent to each user telling him to retype his entire program, or the teletype will automatically turn itself off and the user must re-initiate his connection with the computer.

USE OF PUNCHED PAPER TAPE

To protect against loss of information due to various kinds of hardware malfunctions, it is advisable for persons who must type lengthy programs to make a paper tape copy of their teletype input. If it should become necessary to retype a long program, the paper tape can then be read in instead. A paper tape may be produced while actually inputting

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to the computer, or it may be prepared ahead of time by using the teletype
in the local mode.  A paper tape may not be copied while it is being input
to the computer.

ON-LINE PAPER TAPE PREPARATION

To prepare a tape while inputting to the computer on a model 35 remote,
after establishing the connection, turn on the punch input switch (the
second of the three toggle switches) and then press the KT button.  The KT
button will light and the K light will go out.  The paper tape punch will
now operate only when the KEYBOARD SEND light is on.

At the beginning of each line of input, type two RUBOUT characters.
These are necessary because of timing considerations in the paper tape
reader and carriage return mechanism.  They also serve to mark the end
of each line on the tape clearly for visual inspection.  The reason that
a tape prepared in this manner may not be copied while it is being input
to the computer is that, in this case, only one of the RUBOUTs would be
copied.

Each TAB must be followed by one or more RUBOUT characters, because
of similar timing considerations in the tape reader and the TAB  mechanism.

The punch may be turned off at any time by pushing the K button and
may be turned on again by pushing the KT button.

If the punch contains a print mechanism, the printing of the tape
trails the corresponding punched character by $6\frac{1}{2}$ character positions.
Only visible characters are printed.  The following characters are printed
differently by the paper tape printer than by the page printer:

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| character | printed on tape | character | printed on tape |
|-----------|-----------------|-----------|-----------------|
| ¬ | ! | ' | ← |
| + | " | \| | a |
| → |   | ( | [ |
| = | % | ) | \ |
| ← | & | : | + |
| [ | ' | > | ↑ |
| ] | ( | < | ] |
| \ | ) | ↑ | < |
| ∨ | * | ↓ | > |
| * | = | / | ? |
| ∧ | : | 10 | / |

The paper tape printer is turned on and off by a lever on the lefthand side of the punch unit. Tpaes prepared on modified Carnegie Tech teletypes may be used on standard teletypes and vice versa, but one should contact the center for the proper techniques.

ENTERING A PUNCH TAPE ON LINE

Press the square red button on the tape reader to open the cover. Insert the tape as it came out of the punch, printed side up, with the first punched character to be read positioned over the reading pins. Snap down the cover. Then the reader is turned on by pressing the TD ON button at any time after the computer has acknowledged the connection. The reader will then start reading each time the KEYBOARD SEND light comes on, and stop reading at the end of each line.

The reader will stop two characters after reading the control character XOFF (CTRL-S), unless the character following the XOFF is a RUBOUT in which case the reader will stop reading after the RUBOUT. It may also be stopped manually by pressing the TD OFF button.

The green RUN-FREE lever on the tape reader must be held to the left if it is desired to reposition the tape by moving it backwards.

OFF-LINE PAPER TAPE PREPARATION

To prepare a paper tape for later computer entry, without inputting
at the time the tape is created, put the teletype in the local mode by
pressing the LCL (local) button in the right-hand control group.  Turn off
the punch input switch (second of the three toggle switch).  The proce-
dure is then essentially the same as for on-line preparation.

Errors on the tape being punched may be corrected by using the red
LOC BSP key to backspace the tape punch and then punching RUBOUT charac-
ters over the characters in error.  (Each of these actions [LOC BSP and
RUBOUT] is invisible to the computer, so this method of error correction
will not work when actually inputting to the computer.)

OFF-LINE PAPER TAPE LISTING

A paper tape may be listed without inputting to the computer, by
putting the teletype in the local mode and operating the tape reader as
for on-line entry.

REPLACING PAPER, RIBBON, OR TAPE

Refer to the "Teletype Operating Instructions" booklet or report
the condition to the computer operator.

REPORTING MALFUNCTIONS

All teletype or system malfunctions should be reported to the
computer operator at once by telephone.  The report should include the
remote number of the teletype and the channel involved.

# EXPLANATION OF TELETYPE CONTROLS FOR "35" REMOTE

## TURN-ON AND TURN-OFF CONTROLS

On the lower right-hand corner of the "35" remote teletype is
a group of six buttons:

ORIG (originate) -- This button is pressed to obtain a dial-tone
in order to call the computer. This button will be lit while the
teletype is connected to the telephone line if the connection was
initiated by the teletype.

CLR (clear) -- This button is pressed to disconnect the teletype
at the end of a call or to turn off the teletype if it is in the
"local" mode.

ANS (answer) -- When the teletype is "out of service" or in the "local"
mode, the light under this button will flash to indicate an incoming
call. This button is then pressed to answer the call. When the tele-
type is off, incoming calls will be answered automatically. This button
will be lit while an incoming call is in progress.

TST (test) -- This button is to be used only by the telephone company.

LCL (local) -- This button is pressed to put the teletype into the
"local" mode from the off condition. In the "local" mode, the tele-
type may be used as an electric typewriter of for the preparation
or listing of paper tape and is effectively disconnected from the
telephone line. When the machine is in the "local"mode, the light
behind the "LCL" button is lit.

BUZ-RLS (buzzer-release) -- The light behind this button lights
whenever the paper supply is almost out. At that time a buzzer will
sound. The buzzer may be silenced by pressing this button. Above
this set of buttons is a regular telephone dial and a card-dialer. On
some teletypes, the regular dial is disconnected and only the card-
dialer may be used.

CARD DIALER CONTROLS

Just above the regular dial is the card-dialer unit. Just below
the slot are two control bars:
RELEASE -- Releases the plastic card so that it may be removed.
START -- Starts the card-dialer after the correct card has been inserted
and pushed all the way down.

CONTROLS IN UPPER RIGHT-HAND CORNER

BRK-RLS (break-release) -- This lamp will light when more than 96 char-
acters have been typed in a line, and after pressing the BREAK button.
It may be ignored.
REST (restrain) -- Has no function on our modified teletypes
OUT-OF-SERVICE (out-of service) lamp
out-of-service switch                    The out-of-service switch is
turned to point to the OUT-OF-SERV lamp to take the station "out of
service" while replacing paper or ribbon. When in this condition, the
OUT-OF-SERV lamp will be lit. Whwn the paper or ribbon has been re-
placed, the teletype should be re_urned to servicre by turning the
switch momentarily to the RESTORE position (until a dial-tone is heard)
and then returning it to the NORM position. The teletype should not
be left in the "out-of-service" state for any longer than it is necessary.

LEFT-HAND PANEL

TD CALL IN -- ("TD" stands for "tape distributor") -- Has no function
on modified teletypes.
TD OFF -- Stops the paper tape reader
TD ON -- Starts the paper tape reader
ROTR ON -- ("ROTR" stands for "receiving only typing reperforator")
-- Has no function on our modified teletypes.
HERE-IS -- Should never be used when communication with the computer.
BREAK -- Used to initiate and terminate a conversation with the computer.

THREE TOGGLE SWITCHES

SWITCH 1 (Paper tape teletypes only) -- Punch CTRL Enable -- Enables the control functions of CTRL-R (TAPE) and CTRL-T

SWITCH 2 (Paper tape teletypes only) -- Punch Input -- Causes the paper tape punch to turn on whenever the KEYBOARD SEND light comes on, and to turn off whenever the RETURN key is struck.

SWITCH 3 (The only switch on teletypes without paper tape) -- Duplex -- When the teletype is being used in the local mode, this switch must be off.

KEYBOARD SEND light (yellow) -- when lit, indicates that the user may type information to the computer. When the teletype is connected to the computer, the keyboard is electrically disconnected except when this light is lit.

K -- (keyboard) -- Turns off the paper tape punch.

KT -- (keyboard and tape) -- Turns on the paper tape punch.

T -- (tape) -- Has no function on our modified teletypes.

TTR -- (tape-to-tape receive) -- Has no function on our modified teletypes.

TTS -- (tape-to-tape send) -- Has no function on our modified teletypes.

MOTOR ON -- When turned to the veritcal position, turns the teletype motor on. Has no function on our modified teletypes.


EXPLANATION OF CONTROL CHARACTERS

CTRL-B -- Sent by the computer to tell the teletype it is connected to the computer.

CTRL-C -- Sent by the computer to turn on the KEYBOARD SEND light.

CTRL-D (EOT) -- (end of transmission) -- Causes the teletype to disconnect from the computer (Has the same effects as the CLR button, but may be used only after a connection has been established.)

CTRL-E (WRU) -- (who are you?) -- Has no function in our system.

CTRL-F (END) -- Has the same effect as RETURN except the teletype printer carriage is not returned.

CTRL-G (BELL) -- Rings a bell in the teletype.

CTRL-K (vertical tab) -- Upspaces paper to the next pre-set stop position.*

CTRL-L (form eject) -- Upspaces paper to the next half page.*

CTRL-N -- Sets the ribbon ink color to RED (done automatically by the computer before it types certain messages.)

CTRL-O (letter OH) -- Sets the ribbon ink color to BLACK (done automati-
cally by the computer just before each time the KEYBOARD SEND light is
turned on).*

CTRL-R (TAPE) -- On the model 35 ASR teletype, if the teletype is in the
KT mode and the punch CTRL enable switch (left-hand toggle switch) is on,
then this control character will turn on the paper tape punch.*

CTRL-S (XOFF -- transmitter off) -- On the model 35 ASR teletype, if this
control character is read by the paper tape reader, the reader will stop
after reading the next two characters, unless the character following
the XOFF is a RUBOUT character, in which case the reader will stop after
reading the RUBOUT.

CTRL-T -- On the model 35ASR teletype, if the teletype is in KT mode
and the punch control enable switch is on, then this control character
will turn off the paper tape punch, after itself being punched into
the tape.*

CTRL-U (ERROR) -- This control character is typed just before the RETURN
which signals the end of a line, to indicate that the entire line is to
be retracted.


INDEX OF CONTROL LINES

   $= BACKSPACE {character} -- specifies the backspace character.

   $= CANCEL -- If typed during the wait phase before program execution
has begun, the program will not be run. If typed after program execution
has begun, the computer will type RUNNING on the teletype and the program
will continue to run.

   $= MESSAGE -- Prints the remote stations message buffer.

   $= OUTPUT -- Prints the most recent file for this teletype.

   $= SETTO {line number} * -- Sets the line counter. The asterisk must
be present if the line counter is to be set to a value greater than the
maximum line number typed out be the computer in this conversation.


*  When any of the control characters K, L, N, O, R, or T is punched into
   a tape, it must be followed by a RUBOUT.

$= TABS {language}: $C_1$, $C_2$, ..., $C_8$ -- Defines the user's own
language and prescribes the corresponding TAB interpretation to be used,
as described above.

$= TELL -- Prints the common message file.


INDEX OF AUTOMATIC MESSAGE

CIT REMOTE nn -- Identifies the teletype being used.

a OPER bbbb cc ccc cc d

ee:ee:ee BEGIN

'a' (which may be blank) indicates the current mode of computer operation
(G-20 or G-21) and which central processor is in connection with this
teletype; 'bbbb' is the man number of the current computer operator;
'cc ccc cc' is today's date; 'd' identifies the channel in use, i.e.,
to which of the computer's 16 incoming telephone lines this teletype is
now connected; 'ee:ee:ee' is the time of day in hours, minutes, and
seconds (24-hour clock).

*$= -- Only control lines may be typed.

REMOTE NOT IN OPERATION -- programs may not now be entered from this teletype.

ILLEGAL USAGE -- Teletype program entry is currently restricted to Computa-
tion Center staff members.

nn:nn:nn WAITING -- The program is now waiting its turn to be run.

:$= -- You may now type one control line.

PROGRAM EXECUTING -- Execution of the program just entered from this
teletype has just begun.

nn:nn:nn END -- All teletype output from this program has been printed.

WHAT -- an illegal control line was just typed and will be ignored.

OUTPUT TERMINATED -- Teletype output has been terminated by the user; the
remainder has been discarded.

INPUT EXCEEDED - LINE NOT ENTERED -- Programs entered from teletypes are
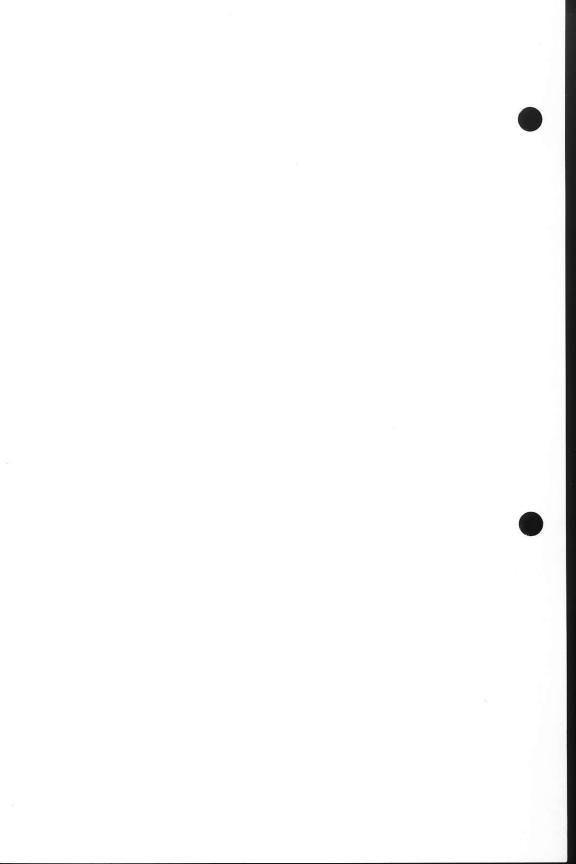restricted to 209 lines of input.

EXTENDED INTERNAL G-21 CHARACTER SET

FOR TELETYPE INPUT-OUTPUT *

| | | | BIT NUMBER | | | | | |
| | | | 654 | | | | | |
| 3210 | 000 | 001 | 010 | 011 | 100 | 101 | 1̄10 | 111 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|
| 0 0 0 0 | space | P | 0 | = | | p | FULL | POFF |
| 0 0 0 1 | A | Q | 1 | $\vee$ | a | q | SOM | XON |
| 0 0 1 0 | B | R | 2 | $\neq$ | b | r | EOA | TAPE |
| 0 0 1 1 | C | S | 3 | $\wedge$ | c | s | EOM | XOFF |
| 0 1 0 0 | D | T | 4 | < | d | t | EOT | ~~TAPE~~ |
| 0 1 0 1 | E | U | 5 | $ | e | u | WRU | ERROR |
| 0 1 1 0 | F | V | 6 | > | f | v | END | SYN |
| 0 1 1 1 | G | W | 7 | ; | g | w | BELL | LEM |
| 1 0 0 0 | H | X | 8 | ( | h | x | $FE_o$ | $S_o$ |
| 1 0 0 1 | I | Y | 9 | [ | i | y | H TAB | $S_1$ |
| 1 0 1 0 | J | Z | 10 | ] | j | z | LF | $S_2$ |
| 1 0 1 1 | K | \| | . | ) | k | | V TAB | $S_3$ |
| 1 1 0 0 | L | $\leftarrow$ | + | $\downarrow$ | 1 | ACK | FORM | $S_4$ |
| 1 1 0 1 | M | $\rightarrow$ | - | $\uparrow$ | m | ALT MODE | RET | $S_5$ |
| 1 1 1 0 | N | $\neg$ | * | : | n | ESC | RED | $S_6$ |
| 1 1 1 1 | O | , | / | ' | o | DEL | BLACK | $S_7$ |

* Characters are normally masked with $77_8$ before printed on the line printer.
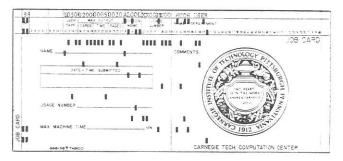
MAKE UP OF THE PROGRAM DECK

The C.I.T. Software Systems are organized to accept and interpret the
card-image as the basic unit of input.  Each card-image is a one-
dimensional array of 84 character columns.  Although this is true of
AND text and teletype line input, card input is limited to 80 columns;
columns 81-84 contain AND sequence numbers.

A representative program card-deck is illustrated on the preceding
page.  The deck has three principal components:  The Job Card (orange),
source program cards and data cards.

THE JOB CARD

The Job Card provides an entry for all information <u>about the program</u>.



| Columns | Data |
|---------|------|
| 1 and 2 | $$ . . . . . . . (Job Card language code) |
| 3 and 4 | Not significant |
| 5 | Not significant (except for teletype entry-extra time) |
| 6 | Bit configuration to prevent an area of disc to be written on by one machine while another is using it. |

| Program Intending To Write On Disc Area | Bit To Be Punched |
|------------------------------------------|-------------------|
| The ALGOL Library | $0 |
| The GATE Library | $1 |
| Computation Center Records | $2 |

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| Program Intending To Write On Disc Area | Bit To Be Punched |
|---|---|
| Temporary GATE-ALGOL Segments | $3 |
| TEACH Records | $4 |
| FORTRAN Library | $5 |

| Columns | Data |
|---|---|
| 7 thru 11 | Not significant |
| 12 thru 15 | User tape number (if any) |
| 16 thru 19 | Number of cards of output (maximum) (if any) |
| 20 thru 23 | Compile, Assembly, or loading time plus execution time (maximum) |
| 24 thru 27 | Number of pages of printed output (maximum) |
| 28 thru 32 | Language system in source program |
| 33 thru 40 | Usage number |
| 41 thru 75 | Name and Department |

SOURCE PROGRAM CARDS

These cards contain the program in the language system specified by
the Job Card (columns 28 thru 32). Columns 1 and 2 in source program
cards are reserved for the first two letters of the language system that
the program uses. These columns may be left blank, however, because a
prior card (the Job Card) has already designated a language system.
In programs that run in one language system but can call other language
systems, the first card of the embedded system must carry its own
column 1 and 2 system-designator. Likewise, in returning to the
original language system, the first return card must, once again, carry
the original designator in columns 1 and 2. The columns-4-thru-80
content of source program cards is language-dependent.

DATA CARDS

There are no fixed-field conventions for Data cards. The assignment of
columns of fields of card columns is unconstrained--the User may insert
data to suit his purposes.

## TAB TABLE

Most languages require a fixed field convention; that
is, certain information belongs in specific columns
of the card image. To facilitate this Tab conventions
have been established. On the keypunch, tabs depends upon
drum cards.     The TAB on the teletype
unit is a control key; it is not a character of the
program data. It has the effect of moving the column
pointer of the card image to specific position. The
meaning (or control effect) assigned to tab is dependent
upon the language specification in columns 1 and 2
of the card-image containing the tab. Interpretation
of tabs for each of the CIT   language systems is as
follows:

### TAB TABLE

| Language Designator | | Interpretation | First Column |
|---|---|---|---|
| (blank) | Same as language last specified. If no language is previously specified, the line is ignored. | | |
| $$ | JOB CARD | | |
| | 1st TAB | TIME | col. 20 |
| | 2nd TAB | PAGES | col. 24 |
| | 3rd TAB | SYSTEM NAME | col. 28 |
| | 4th TAB | USAGE NUMBER | col. 33 |
| | 5th TAB | NAME - DEPARTMENT | col. 41 |
| AN | AND | | |
| | 1st TAB | STATEMENT | col. 4 |
| AL | ALGOL | | |
| | 1st TAB | (3-column | col. 4 |
| | 2nd TAB | indentation) | col. 7 |
| | 3rd TAB | " | col. 10 |
| | 4th TAB | " | col. 13 |
| | 5th TAB | " | col. 16 |
| IP | IPL-V | | |
| | 1st TAB | TYPE | col. 41 |
| | 2nd TAB | NAME | col. 43 |
| | 3rd TAB | PQ | col. 49 |
| | 4th TAB | SYMB | col. 51 |
| | 5th TAB | LINK | col. 57 |
| | 6th TAB | COMMENTS | col. 62 |

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| Language Designator | | Interpretation | First Column |
|---|---|---|---|
| TH | THAT | | |
| WH | WHAT | | |
| | 1st TAB | LABEL | col. 4 |
| | 2nd TAB | OPCODE | col. 15 |
| | 3rd TAB | MODE | col. 20 |
| | 4th TAB | ADDRESS, REGISTER | col. 24 |
| | 5th TAB | COMMENTS | col. 40 |
| CO | COMMENT CARDS - ALL TABS are accepted as input characters. | | |
| DA | DATA CARDS FOLLOW - The language is set to COMMENT and the line ignored. | | |
| GA | GATE | | |
| | 1st TAB | STATEMENT NUMBER | col. 9 |
| | 2nd TAB | STATEMENT | col. 15 |
| | 3rd TAB | COMMENTS | col. 40 |
| SC | SCADS | | |
| | 1st TAB | STATEMENT NUMBER | col. 3 |
| | 2nd TAB | OPCODE | col. 8 |
| | 3rd TAB | PARAMETER | col. 13 |
| FO | FORTRAN | | |
| | 1st TAB | STATEMENT NUMBER | col. 3 |
| | 2nd TAB | STATEMENT | col. 7 |
| \|\| | ALGY CONTROL CARD | | |
| | 1st TAB | TASK | col. 7 |
| | 2nd TAB | PARAMETER 1 | col. 17 |
| | 3rd TAB | PARAMETER 2 | col. 22 |

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The computer uses punched cards as an input medium for pro-
grams and for data. Information is represented on these cards
by the presence or the absence of holes in a 12 row (down) and
80 column (across) array on a card.

The rows 0 to 9 (down) provide ten rows. There are
two other unmarked rows at the top of the card. These are called
the plus (+) or 12 row and the minus (-) or 11 row. Thus, ordered
from the top, the rows are +, -, 0, 1, ......,9. The top edge
is called the 12 edge , while the bottom is the 9 edge .

The machine used to prepare punched cards is called a key-
punch, which is essentially a typewriter that punches holes in the
card and prints above each column the information punched in that
column. It has operations and controls not found on most type-
writers. A diagram of the keyboard and controls will be found at
the end of this guide.

BASIC OPERATIONS

The gray keys on the keypunch are identical to those of a
typewriter. The blue keys are the special features of the key-
punch. At the top right-hand side of the keypunch is a hopper
for the blank cards to be keypunched. The cards are placed fac-
ing toward you in the tray. There is a spring-loaded follower in
this tray to push the cards forward. The cards must be between
this and the front of the tray. On the left-hand side of the
machine at the top is the TURN ON switch. There is a long warm
up period for these machines, so do not become impatient waiting
for them to start.

Notice the blue V-shaped handle located at the center of the
machine just below the plastic window. This lever controls the
keypunch in two ways.

1. Turned to the right, it shuts off the program drum con-
trol and makes the keypunch an alphabetic typewriter
available to punch all 80 columns on each card.

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2. Turned to the left, this handle sets the machine into automatic control, regulating the punching from the programmed drum card placed around the drum wheel. This will not work without the drum card on the wheel under the plastic window. Removal of the drum can only occur when the lever is turned to the right. Never force the drum wheel into the machine, or pull it out of the machine with force.

The three keys to the center of the keyboard at the top marked AUTO FEED, AUTO SKIP and PRINT are needed to control the flow of cards into the machine, the printing on the top of each card, and the auto-control from the program drum.

The keypunch is like a typewriter except that it does not punch lower case letters. The shift keys located off either side of the keypunch board are labeled NUM and ALPH. The NUM key when pressed down will punch the numbers and special characters shown on the upper portion of the keys. The ALPH of alphabetical shift punches the alphabet and the special characters on the lower portion of the keys.

TO PUNCH WITH THE KEYBOARD AS A TYPEWRITER

Place the cards in the hopper. Turn blue V-shaped handle under plastic window to the right. Turn the auto-dup, auto-feed and print buttons on. Hit the REL key (right-hand side) twice. Start punching. If you make a mistake, hit the release button and begin again. Note the column indicator inside the plastic window. Each time a column is punched, the indicator moves one place. This is to tell you what column you are ready to punch into. The long lines on the indicator are the odd numbers, the short ones, the even numbers .

Duplication from one card to another is possible by holding down the DUP button (top of keyboard). The duplicating button duplicates one column at a time from the preceding card. If an error has been made in a card, say column 65, hit the

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release button; then, push down the duplicating button until the indicator shows column 65, correct the error and continue punching.

## TO BACKSPACE

Below the card channel is a large gray button that will backspace the card one column at a time both in the reading and the punching stations. Backspacing will not erase holes. If the keyboard jams, pressing the backspace button will release it.

## MULTIPLE PUNCH

The MULT PUNCH key keeps the keypunch from spacing while it is held down, so that several punches can be put in one column. This will not work on alpha keys--only the numbers. ALGOL and several other CIT programming languages use characters which are not built into the keypunch. These characters must be punched by holding down MULT PUNCH while pressing the two or three numeric keys for that character. While MULT PUNCH is pressed, the keypunch is automatically in numeric shift so it is not necessary to hold down both the NUM and MULT keys simultaneously.

## DRUM CARD CONTROL

A suitable drum card can make keypunching much easier when there is much of it to be done in a fixed format. The facilities provided by drum cards for formatting are convenient when certain columns are assigned special significance. A suitable program card can automatically:

    a. Make the SKIP key serve as a tab key, causing the punch to move the card to the next specified column.

    b. Skip selected columns automatically.

    c. Duplicate selected columns automatically from the previous card punched.

    d. Place the keypunch in numeric shift for punching purely numeric information unless the ALPH key is depressed.

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Once the right end of the card is seated properly, move the
the lever to its center position. This will secure the right end
of the card. Wrap the drum card tightly around the drum and
slip the free end under the prong side of the chrome strip.
Make sure the card is wrapped tightly around the drum and move
the lever to the right to lock the card in place. To replace
the drum, the needle spindle is at the bottom. Close the cover;
it fits over card Col.1 of the number indicator in the machine.
Turn the blue drum card control button to the right, the
AUTO FEED , AUTO DUP AUTO SKIP , and PRINT switches on and
begin punching under Drum Card Control.

Note that the gray key next to the MULT button shows the
characters ($\bar{\bar{\tau}}$). All the keypunches are internally wired to punch
a semicolon (;) in the alpha shift. The print will show a quote
(') but the holes punched in the card are 4, 8, which is read by
the computer as a semicolon. The computer reads holes, not print.
When multipunching, the printing will be smudged. Also, if
you duplicate a card with more than two holes per column, the
printing mechanism will not always work. Sometimes it prints a
6 or 8; however, it doesn't matter as long as the correct holes
are in the card, because the computer reads holes.

WARNING:  Never try to use the keypunch to duplicate a card
containing more than three punches in a column. The machine will
give up and die if you try it. (Binary cards and cards bearing
a design in the punches almost always contain more than three
punches in some column.) There is another machine, the IBM Model
519 Reproducer, which can copy these cards. However, the 519
will not print (interpret) the punches on any card. There is another
machine that does this.

How To Make A Drum Card

A drum card is in effect a small program because it tells the
keypunch machine how to adjust to a definite pattern for punching.

First decide where the information is to be punched in the
card, then whether the information to be punched is numeric or

alphabetic. The columns set aside for punching specific information are called a field. A single card may have any number of fields or groups of information punched into it. The fields are treated on a keypunch as tabulator stops are on a typewriter, except the tab stops are made by the drum card. Thus, one can automatically skip or stop at any column on the card merely by coding a single program drum.

The codes used to program a drum card are:

| Code | Definition |
|------|-----------|
| — | Skip |
| 0 | Duplicate the information on previous card |
| 1 | Go onto alphabetic skip |
| + | Continue skiping on duplicating |

* Note: Each time a group of columns is assigned, that field must be defined to the keypunch machine. To tell the machine where another field begins, do not simply put a + sign in the first column of that field, but insert the + in every column that is assigned to that field. For example, if alphabetic information were to be punched in Columns 6-37, then a 1 (alpha code) must be punched in Col. 6. Col. 7-37 would contain both a + and a 1. The + to tell the length of the field and the 1 to punch alphabetical characters.

MULTIPLE PUNCHED CHARACTERS

| | | | |
|---|---|---|---|
| : = 0 2 8 | | ↑ = + 2 8 |
| ' = 5 8 | | ↓ = 7 8 |
| ≠ = - 2 8 | | [ = 0 5 8 |
| ∴ = 0 7 8 | | ] = 0 6 8 |
| → = - 7 8 | | < = - 5 8 |
| ← = 6 8 | | > = - 6 8 |
| ∧ = + 6 8 | | | = 2 8 |
| ∨ = + 7 8 | | ¬ = + 5 8 |