RECOMP II USERS' PROGRAM NO. 1013

PROGRAM TITLE: FM 151 RADIOACTIVE DECAY DEMONSTRATION FOR RECOMP II COMPUTER

PROGRAM CLASSIFICATION: Service Routine

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PURPOSE: After entering the time of the atomic explosion that caused the present radioactivity level, the computer will give upon command; (1) a report of all entered positions as to its location, its measured intensity, and the time of measurement, (2) a report of any or all entered positions at any given time as to the remaining radiation level and if it is dangerous or not, and (3) the time when the radiation level will be safe if it is not already safe.

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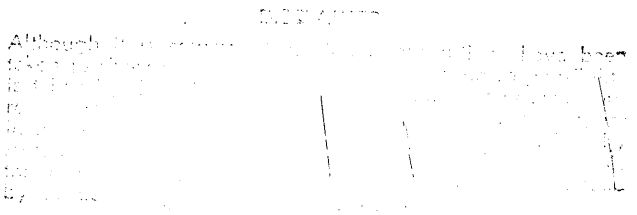

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RADIATION DECAY DEMONSTRATION

1. Introduction:

The Radiation Decay demonstration is capable of storing for one to sixteen different positions; information as to location of the position, the radioactivity intensity level at the position, and the time of the radioactivity intensity reading. This data may be entered in any random order either manually using the typewriter or automatically using the photo-tape reader.

After entering the time of the atomic explosion that caused the present radioactivity level, the computer will give upon command; (1) a report of all entered positions as to its location, its measured intensity, and the time of measurement, (2) a report of any or all entered positions at any given time as to the remaining radiation level and if it is dangerous or not, and (3) the time when the radiation level will be safe if it is not already safe. The saftey level that is considered safe can be determined in advance by the operator in order to adjust to battle conditions.

Attention is brought to the word "demonstration" in the title of this program. A very accurate prediction of intensity levels cannot be determined without additional information such as weather conditions, wind speed and direction, type of bomb, previous radiation level before the bomb explosion and more accurate formulas. These omisions were purposely made in order to have a less confusing and faster operating demonstration. Under average conditions, the answers produced by the demonstration should be within a few percent of the correct value.

The typewriter should be loaded with 8 inch or wider paper, the switch under the type bin cover should be set to execute "tabs" from the computer, and the tab stops set as given in the summary at the end of this report.

The program descrition starts with an outline of the mathematical theory involved followed by an outline of each of these major sections of the demonstration: Time of Explosion, Position Readings, Position Report, Intensity Level, Intensity Saftey Level, Memory Dump, and Summary.

2. Theory:

Radioactivity intensity decays exponentially from the time of an atomic explosion according to the equation:

$$1) \quad I = I_o e^{-ct}$$

I = intensity at some time after explosion (R)
I_o = intensity at time of explosion (R)
t = time from exposion (hours)
c = decay constant = 0.35

The computer could solve this equation using a normal Talor series expansion such as:

$$2) \quad I = I_o\left[A + Bt + \frac{Ct^2}{2!} - \frac{Dt^3}{3!} \cdots\cdots\right]$$

This solution however would take too many terms to give an accurate answer so by using the same series expanded about infinity instead of zero gives:

$$3) \quad I = I_o\left[A + \frac{B}{t} + \frac{C}{t^2} \cdots\cdots\cdots\right]$$

A resonable accurate answer is now possible with just the first 3 terms. In the exponential equation 1) the value c is determined by the radioactive element involved in the explosion. Normally, many elements are involved, each with different values of c and many of these elements are completly non-radiating within a period of 1.41 hours. A value of c that is an approximation of the radiation decay after an average atomic explosion is 0.35 and values of t less then 1.40 hours are considered the same as t = 1.40 in order to overcome the high initial inaccuracy brought about by the very fast decay elements of the bomb.

Substituting these approximations into equation 2) results in A dropping out and:

$$4) \quad I = I_o\left[\frac{0.45}{\Delta t} + \frac{1.35}{\Delta t^2}\right]$$

OR

$$5) \quad I = \frac{I_o}{\Delta t}\left[0.45 + \frac{1.35}{\Delta t}\right]$$

$$\Delta t = \left|\text{Time at } I_o - \text{Time at } I\right|$$

Note that Δt is limited to a period of 24 hours after the blast time since no dates are involved.

Normally, however, I_o is not known, so some reading I is taken at any convenient time Δt after the explosion. Equation 6) will then solve for I_o.

$$6) \quad I_o = \frac{I_1 \, \Delta t}{0.45 + \frac{1.35}{\Delta t}}$$

Now, at some time $\Delta t'$ after taking the intensity level I, a new intensity level is desired which will be called I' . Either equation 7) or 8) will solve for I' .

$$7) \quad \text{IF } (\Delta t + \Delta t') > 1.40 \text{ HRS};$$
$$I' = \frac{I_o}{\Delta t + \Delta t'} \left[0.45 + \frac{1.35}{\Delta t + \Delta t'} \right]$$

$$8) \quad \text{IF } (\Delta t + \Delta t') \leq 1.40 \text{ HRS};$$
$$I' = I$$

I' can then be compared against some value (such as 25 R) in order to determine if the intensity is at a safe level or not. If the intensity is not safe, the time t'' at which the intensity level is safe is determined by first solving for t_s, the time of blast to time of safety (equation 9) and then for t'', present time to time of safety (equation 10).

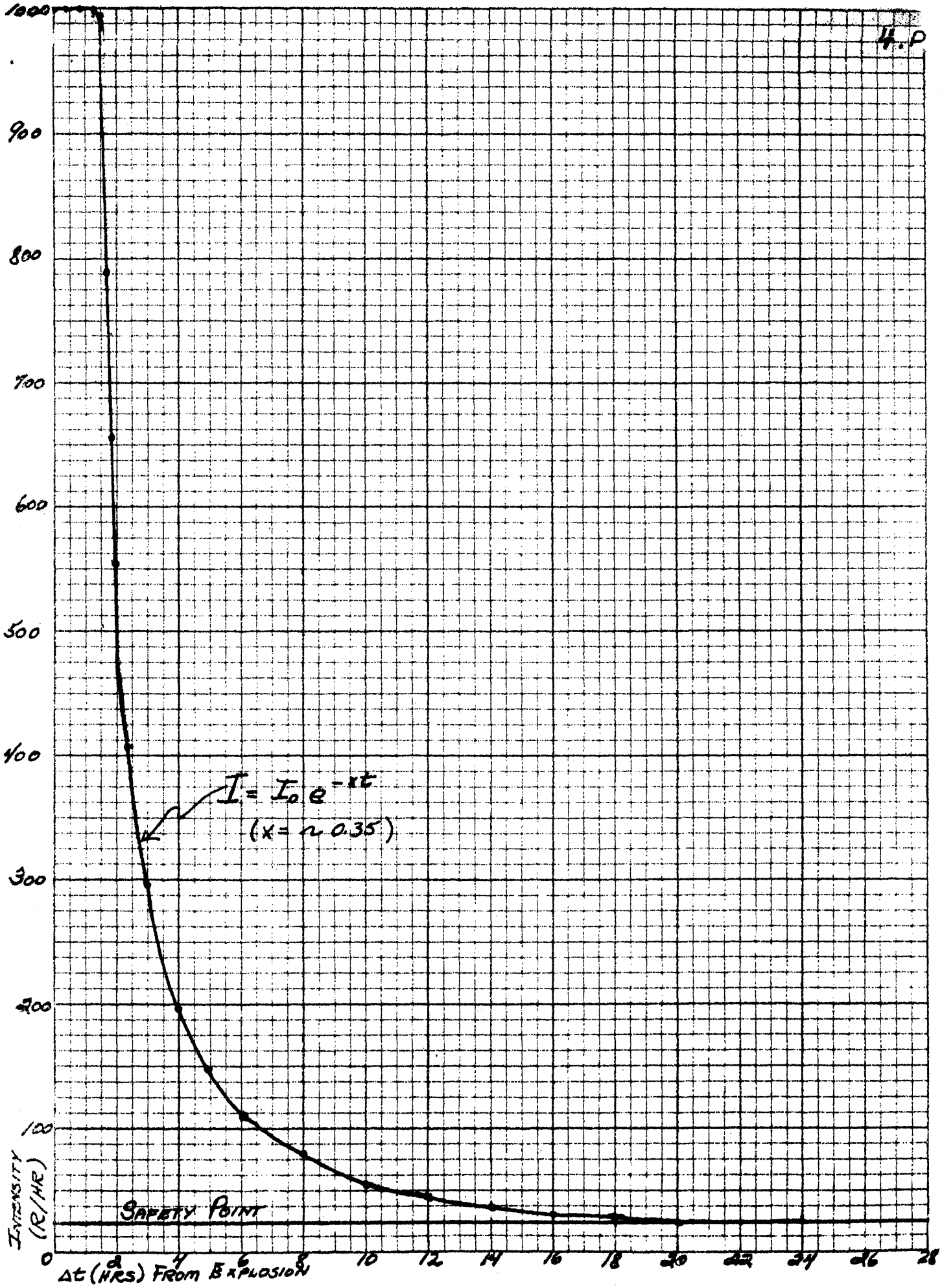
$$9) \quad t_s = \frac{\left[1 + \sqrt{1 + \frac{12 (I_s)}{0.45 \, I_o}} \right] \left[(0.45)(I_o) \right]}{2 \, I_s}$$

I_s = INTENSITY LEVEL CONSIDERED SAFE (R.).

$$10) \quad t'' = (t_s - \Delta t') \text{ HRS.}$$

A graph of the intensity level versus time from explosion as derived by equation 7) is shown in the graph on the next page. Notice that the top of the graph is constant due to the effects of equation 8) (minimizes inaccuracies around the first hour after the explosion).

From the graph it is seen that $I_o = I_1$, where I_1 = intensity one hour after the explosion.


1000
900
800
700
600
500
400
300
200
100
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
$I = I_0 e^{-xt}$
$(x = \sim 0.35)$
SAFETY POINT
INTENSITY (R/HR)
Δt (HRS) FROM EXPLOSION

The plot of this graph is almost exactly the same as that produced by equation no 11:

$$11)\quad I = I_1 t^{-1.2} \quad (R.)$$

t = time to explosion in hours

Equation 11) is presented in the manual "The Effects of Nuclear Weapons" printed by the Department of the Army (DA no. 39-3) in May 1957 and is explained on page 432 as a good approximation of the radiation level at a given point some time after an atomic explosion.

This equation is introduced merely as a check against the presented theory as it was not discovered until after the demonstration was programmed.

3. Time of Explosion:

Pressing preset start button (or transfer to location 5200.0) will cause the computer to ask:

TIME OF EXPLOSION:

Any four digit military time group from 0000 to 2359 is entered. Any deviation from the military time format will cause either

////?????

or

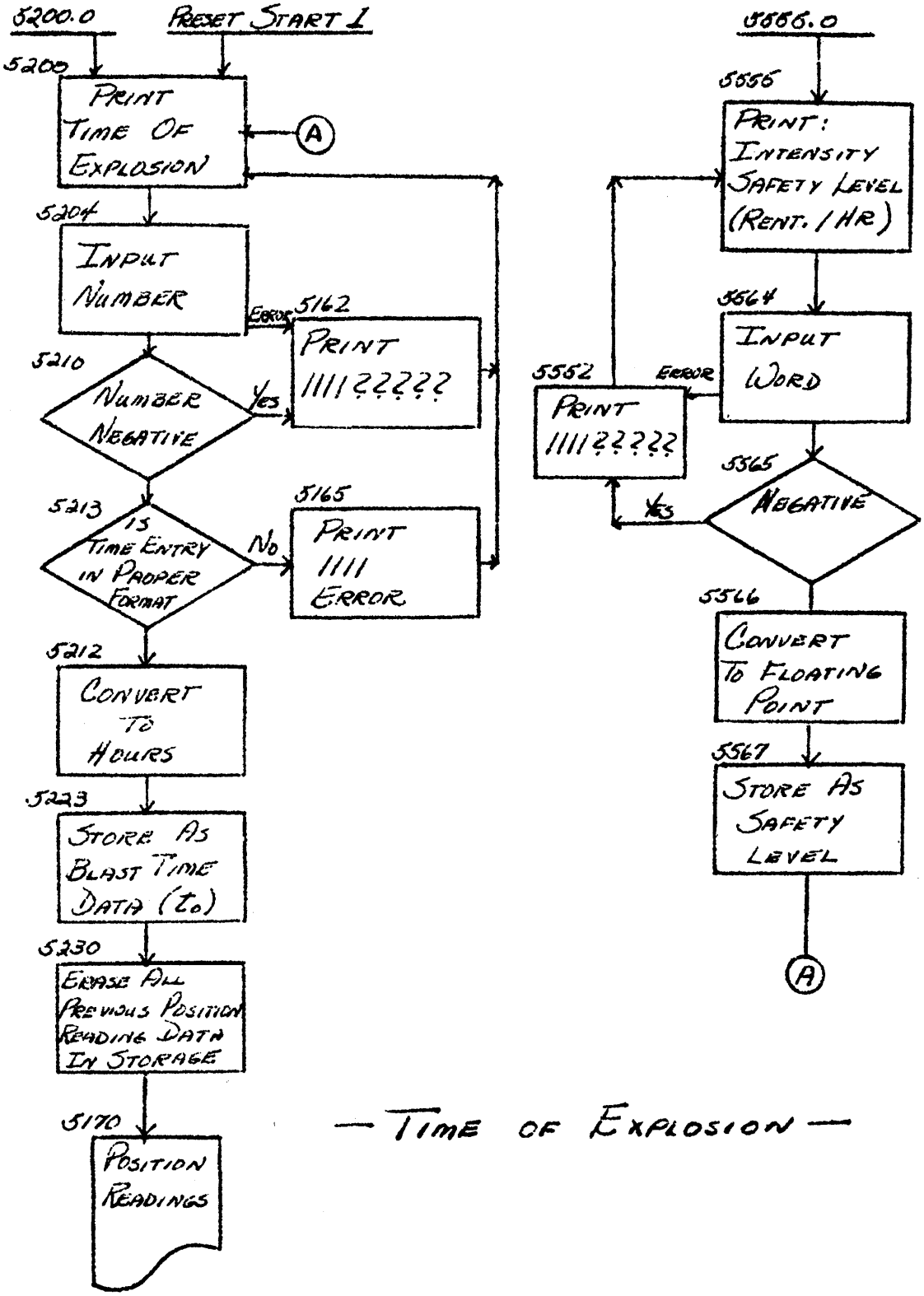
//// ERROR

to be typed and a new time called for. After a time entry has been accepted, all previous intensity readings are erased and the computer asks for new position readings.

4. Position Readings:

Pressing pre-set start button no. 2 (or starting at location 5000.0) will cause the heading "POSITION READINGS" to be printed followed by the question:

POSITION NO:



— TIME OF EXPLOSION —

A number of 1 thru 16 is entered. Negative numbers, non-numeric characters, or numbers over 16 will result in the error print-out:

```
//// NONE
```

After entering a correct position number, the computer asks for the position location.

```
X:
```

and then

```
Y:
```

In both cases, enter a positive integer of five digits or less. A negative entry or a non-numeric entry causes the reply:

```
////?????
```

An entry of more then 5 digits will bring the reminder:

```
//// 5 DIGITS MAX.
```

The time of the radiation intensity reading is asked for:

```
TIME:
```

Enter a 4 digit military time group between 0000 to 2359. Numbers appearing outside of this range or an entry of a non-numeric character causes the statment:

```
//// ERROR
```

Fimally, the intensity reading will be called for with:

```
INTENSITY:
```

Any positive integer may be entered up to 11 digits. Negative entries or non-numeric character entries are detected by the computer and causes the type-back.

```
////?????
```

After the intensity level is entered, the computer converts all entries to the proper format and stores them in the correct locations coresponding to the desired position.

A new position number is called for and the cycle of entries just described is repeated again. As position reading data is entered, any previous information at that position is replaced by the new readings.

A table of all position readings entered will be typed whenever the position number of zero is entered.

In order to automatically enter a complete set of radiation intensity levels, follow these instructions:

(1) Enter time of explosion.

(2) Enter all desired position readings as described in this section.

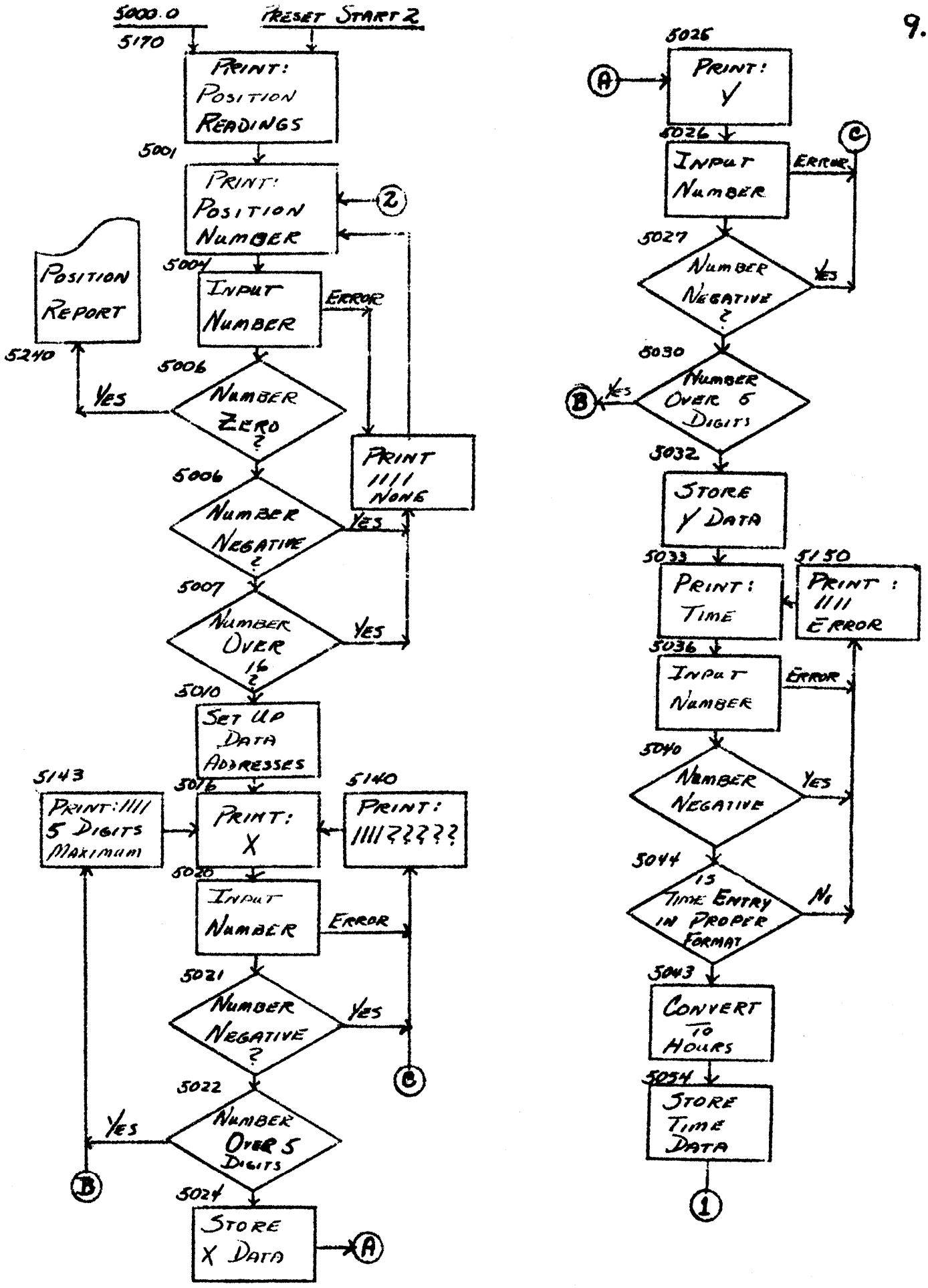
(3) Check entries by printing out the table of all position readings.

(4) Using the inclosed memory dump (see section 8), punch out all data between the locations 5600 to 5777.

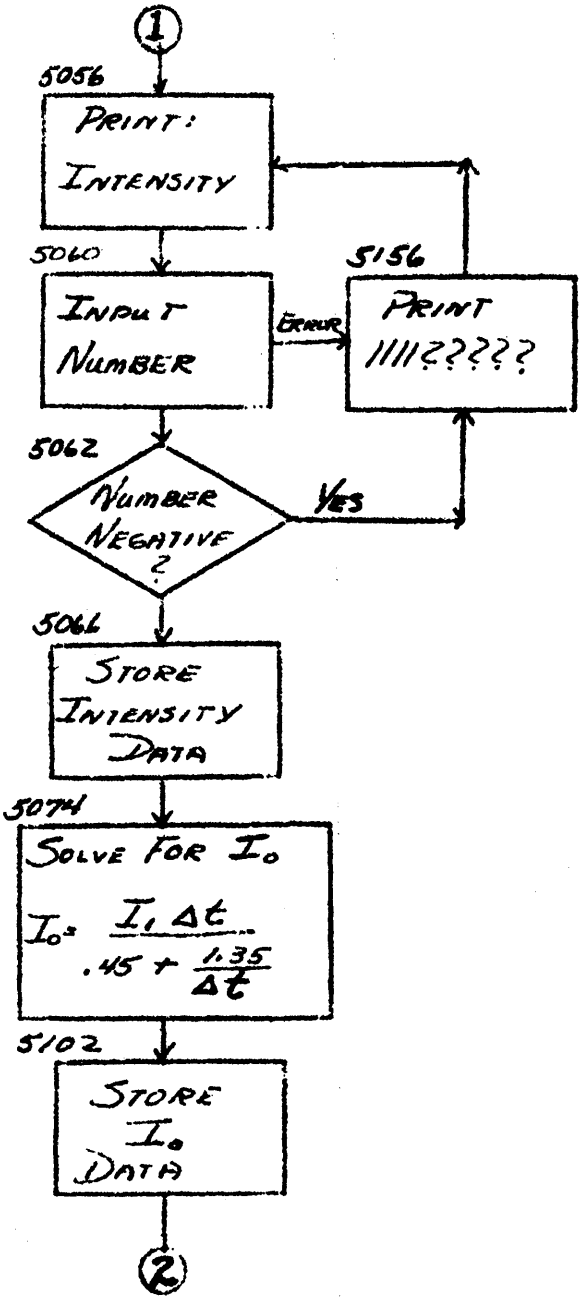
(5) Punch the explosion time data in location 5225 to 5227.

(6) Terminate the tape (also see section 8)

(7) This tape may now be entered at any time by loading the the tape in the photo-reader and pressing the "fill" button. All previous readings will be replaced by those recorded on the tape.



— POSITION READINGS —



— POSITION READINGS —

5. Position Report:

By entering a position no. 0 in the position readings section of the program (pre-set start no. 2) or by starting the computer at location 5240.0, a complete report of all positions entered, their locations, time of reading, and intensity readings are typed in the following format:

POSITION REPORT
TIME OF EXPLOSION: 1023

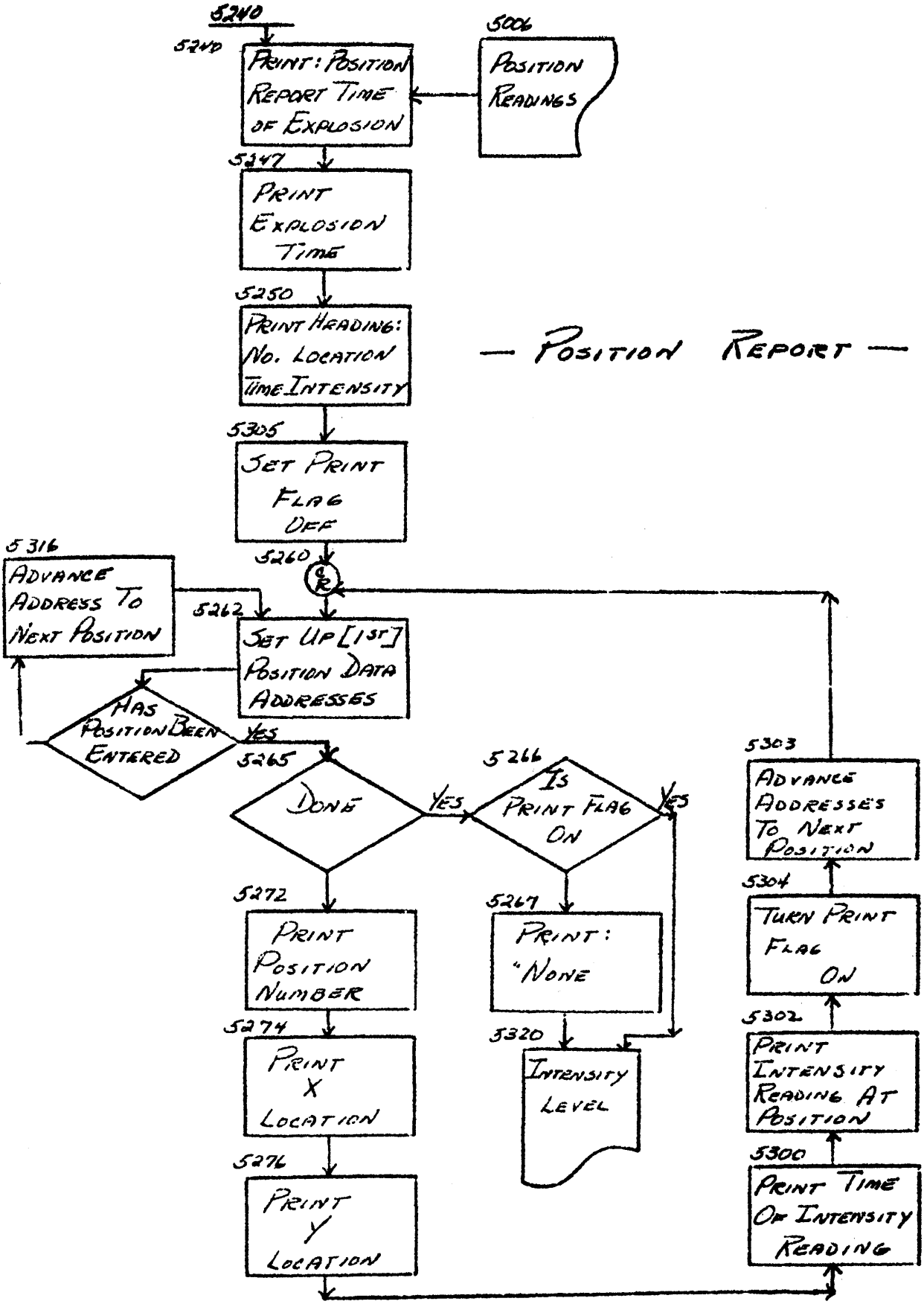
NO.	LOCATION	TIME	INTENSITY
1	12105 00237	1058	400
2	09012 12315	1236	30
5	70000 04000	1309	5
9	00001 02000	0437	1005
14	00305 01212	1334	12
15	04040 40404	2144	19
16	12512 51252	0756	500

If no position has been entered since last entering an atomic explosion time (which will erase all previous readings), then this report is given:

POSITION REPORT
TIME OF EXPLOSION: 1023

NO.	LOCATION	TIME	INTENSITY
NONE			

After either report, control is transfered to the "intensity level" section of the program which is described next.


5240
5240
PRINT: POSITION REPORT TIME OF EXPLOSION
5006
POSITION READINGS
5247
PRINT EXPLOSION TIME
5250
PRINT HEADING: NO. LOCATION TIME INTENSITY
— POSITION REPORT —
5305
SET PRINT FLAG OFF
5260
5316
ADVANCE ADDRESS TO NEXT POSITION
5262
SET UP [1ST] POSITION DATA ADDRESSES
HAS POSITION BEEN ENTERED
YES
5265
DONE
YES
5266
IS PRINT FLAG ON
YES
5303
ADVANCE ADDRESSES TO NEXT POSITION
5304
TURN PRINT FLAG ON
5302
PRINT INTENSITY READING AT POSITION
5300
PRINT TIME OR INTENSITY READING
5272
PRINT POSITION NUMBER
5274
PRINT X LOCATION
5276
PRINT Y LOCATION
5267
PRINT: "NONE
5320
INTENSITY LEVEL

6. Intensity Level:

Preset start switch no. 3, location no. 5320.0, or termination of a "position report" will cause the computer to type the heading and time of the last entered explosion:

```
INTENSITY LEVEL
TIME OF EXPLOSION: 1023
TIME:
```

The last line typed was the request for the time you wish the intensity readings for. Enter a four digit military time group between 0000 and 2359. (note: Since the date is not entered along with the time, as "intensity level" time entries are considered as being within 24 hours of the "position reading" time for each particular position. Also, each "position reading" time is considered as being within 24 hours of the time of explosion. To avoid confusion, try to keep all times, both "position reading" and "intensity level" within 24 hours of the time of explosion.) Time entries that are negative, or not in proper form will result in the reply:

```
//// ERROR
```

The next entry request is for the position number. Enter any positive interger between 0 and 16. Entries other then this will bring the reminder:

```
//// NONE
```

Also, if a particular position number is called for that was never entered, the same reply is given.

Otherwise, the intensity level at the "intensity level" time requested is computed and typed for each position chosen. If the intensity level falls below a pre-set value, the words "NOT DANGEROUS" will be typed instead of the intensity level value. After several "position no:" entries, the format will look like:

```
INTENSITY LEVEL
TIME OF EXPLOSION: 1023
TIME: 2000

POSITION NO: 1          INTENSITY: 232
POSITION NO: 9          INTENSITY: 572
POSITION NO: 2          INTENSITY: NOT DANGEROUS
POSITION NO: 8          //// NONE
```

If the demonstrator desires, a report as to when the intensity level at each position will fall below the pre-set saftey level is also presented. To obtain this additional information, sense switch C must be down. The format for the same previous example will now be:

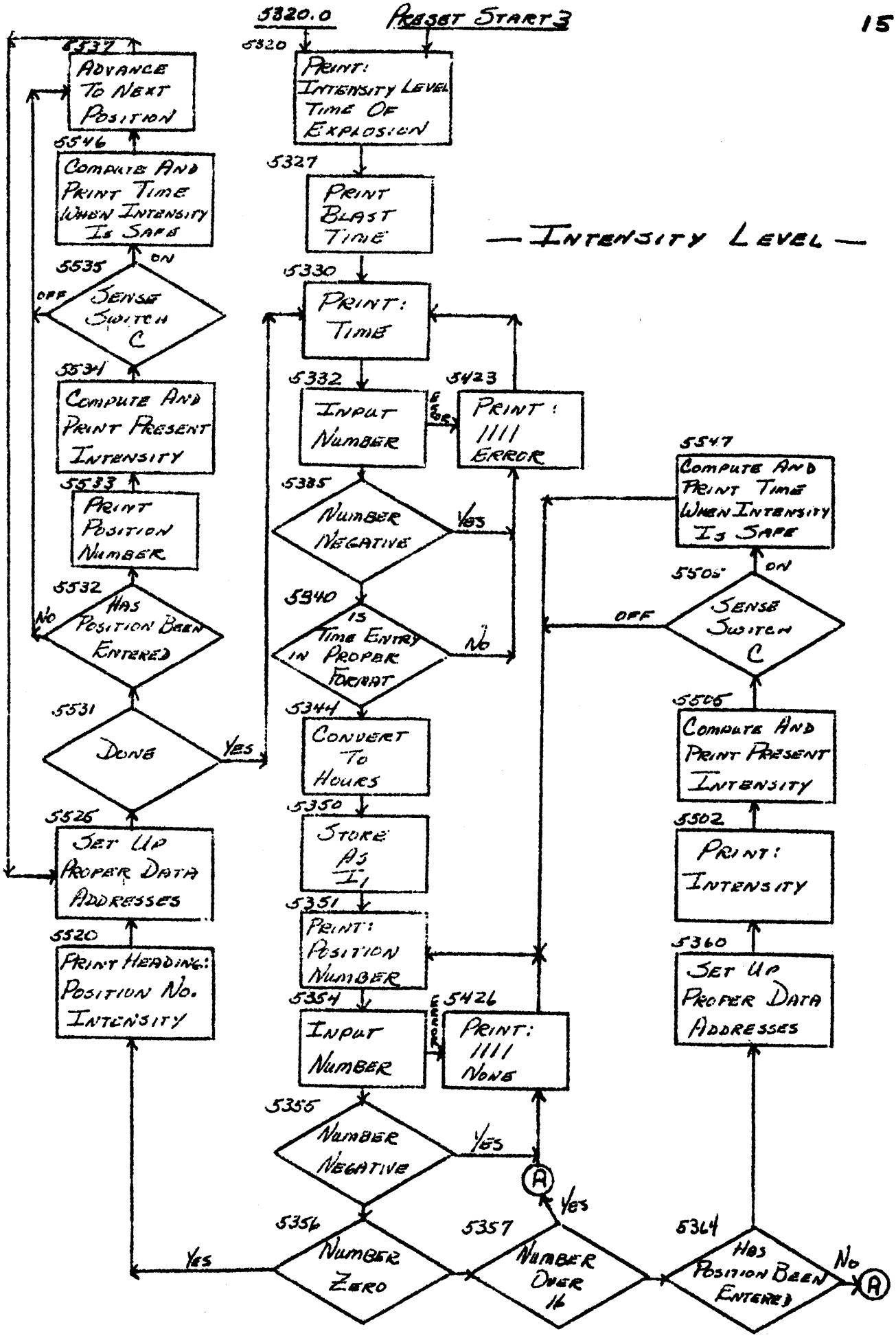
```
INTENSITY LEVEL
TIME OF EXPLOSION: 1023
TIME: 2000

POSITION NO: 1          INTENSITY: 232          SAFE IN 20 HRS, 22 MIN.
POSITION NO: 9          INTENSITY: 572          SAFE IN 47 HRS, 57 MIN.
POSITION NO: 2          INTENSITY: NOT DANGEROUS
POSITION NO: 8          //// NONE
```

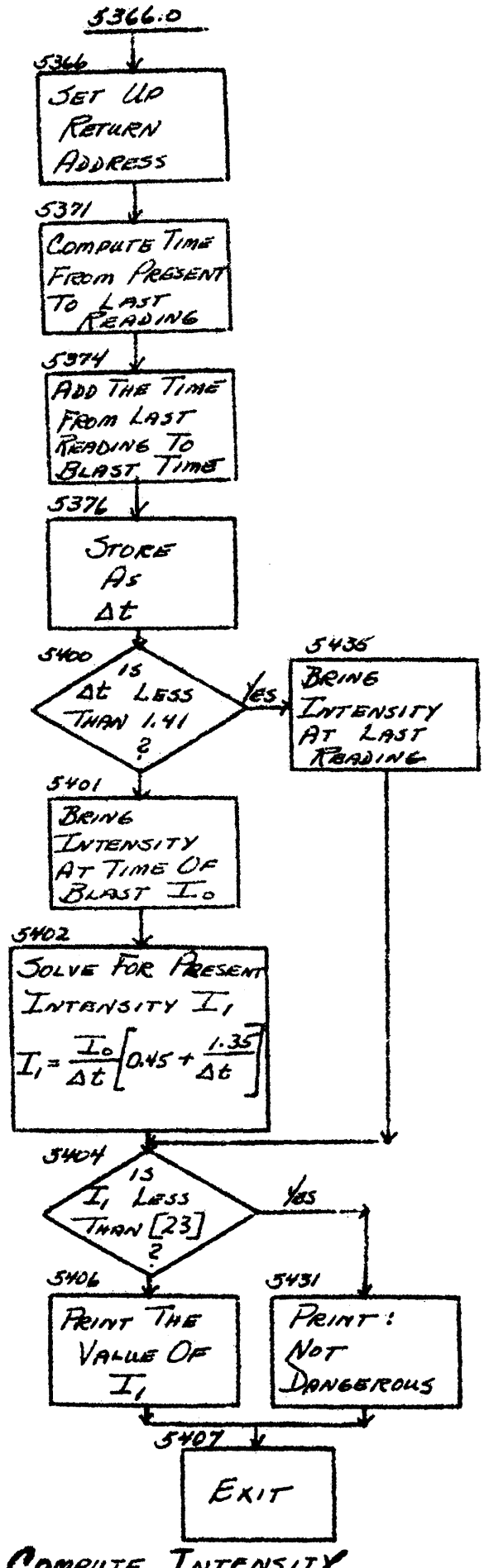
A complete report of what all intensity levels would be for each entered position at any given time can be had by entering 0 (zero) when asked for the position number. Again, if the time at which each position will become "safe" is desired, just turn on (down) sense switch C. Therefore, when asking the computer for position number 0, the computer will type, depending on the position of sense switch C, one of the following examples:

```
INTENSITY LEVEL
TIME OF EXPLOSION: 1023
TIME 2000
POSITION NO: 0
POSITION NO.          INTENSITY
    1                    232
    2                NOT DANGEROUS
    5                NOT DANGEROUS
    9                    572
    14               NOT DANGEROUS
    15               NOT DANGEROUS
    16                   320
```

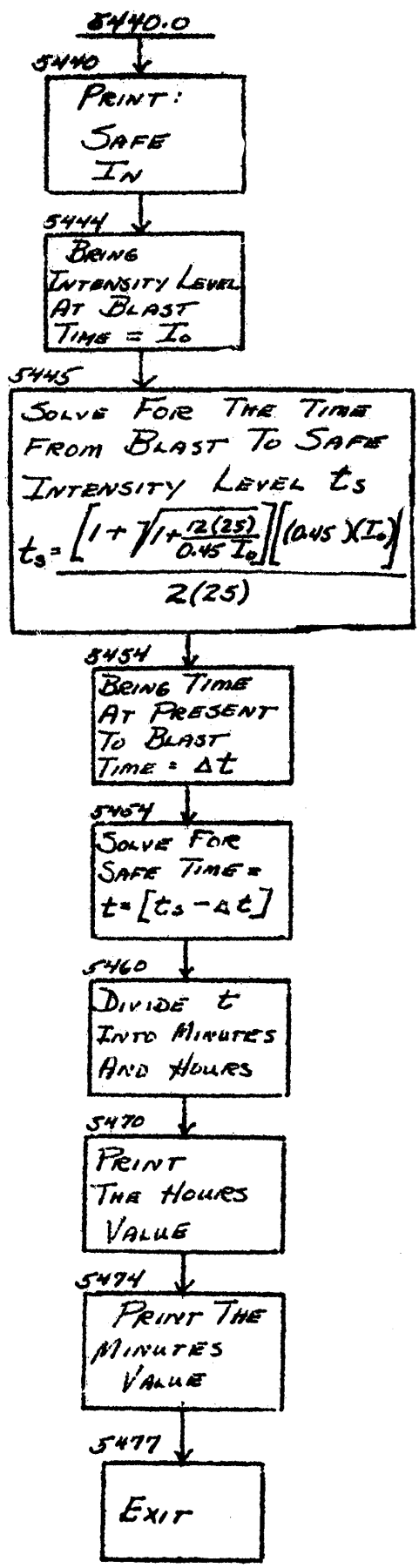
```
INTENSITY LEVEL
TIME OF EXPLOSION: 1023
TIME: 2000
POSITION NO: 0
POSITION NO.          INTENSITY
    1                    232        SAFE IN 20 HRS, 22 MIN.
    2                NOT DANGEROUS
    5                NOT DANGEROUS
    9                    572        SAFE IN 47 HRS, 57 MIN.
    14               NOT DANGEROUS
    15               NOT DANGEROUS
    16                   320        SAFE IN 25 HRS, 8 MIN.
```

When an intensity level is completed, a new time is requested. If no information was entered for any position since the last explosion time was entered, the word "NONE" will be printed under the POSITION NO. column.


5320.0
Preset Start 3
5320
Print: Intensity Level Time Of Explosion
5327
Print Blast Time
5330
Print: Time
5332
Input Number
Error
5423
Print: 1111 Error
5335
Number Negative
Yes
5340
Is Time Entry In Proper Format
No
5344
Convert To Hours
5350
Store As I1
5351
Print: Position Number
5354
Input Number
Error
5426
Print: 1111 None
5355
Number Negative
Yes
A
5356
Number Zero
Yes
5357
Number Over 16
Yes
5364
Has Position Been Entered
No
A
5502
Print: Intensity
5360
Set Up Proper Data Addresses
5506
Compute And Print Present Intensity
5505
Sense Switch C
ON
OFF
5507
Compute And Print Time When Intensity Is Safe
5520
Print Heading: Position No. Intensity
5526
Set Up Proper Data Addresses
5531
Done
Yes
5532
Has Position Been Entered
No
5533
Print Position Number
5534
Compute And Print Present Intensity
5535
Sense Switch C
ON
OFF
5546
Compute And Print Time When Intensity Is Safe
5537
Advance To Next Position
— Intensity Level —



COMPUTE INTENSITY



COMPUTE SAFE TIME

7. Intensity Saftey Level:

Normally, a man can live safely in an area that has a radiation level of 25 R/hr. This is the value used for the "saftey" level in all computations with this demonstration. However, you may wish to change this level to a higher value because the men may all be inside tanks or have protective clothing on, etc. Entering the program at location 5555.0 will cause the computer to ask the question:

```
INTENSITY SAFTEY LEVEL (R/hr):
```

Any positive interger up to 11 digits may be entered without receiving the error reply:

```
//// ?????
```

This value is then stored as the "safe" level until it is again changed by using the same procedure as above.

8. Memory Dump:

The memory dump routine is entered at location 0101.0 and begins by displaying two groups of 4 zeros each on the display tubes.

```
+ 0 0 0 0       0 0 0 0
```

Pressing any octal number key on the keyboard (0 - 7) will cause that number to be entered into the right most digit. As more keys are entered, the last number is entered at the right and the previous numbers shifted left one digit. Only the last eight digits entered are displayed with the "+", "-", "8", and "9" keys being ignored. The "clear" key will reset the display tubes to zero as shown above. The results produced by pressing keys "start", "enter", or "." will be explained separately.

A. Type Memory Contents:

If the "start" key is depressed, the data between the left and right address showing on the display tubes at that time are typed in Recomp command format with a reference address typed every 8 words (one word per line).

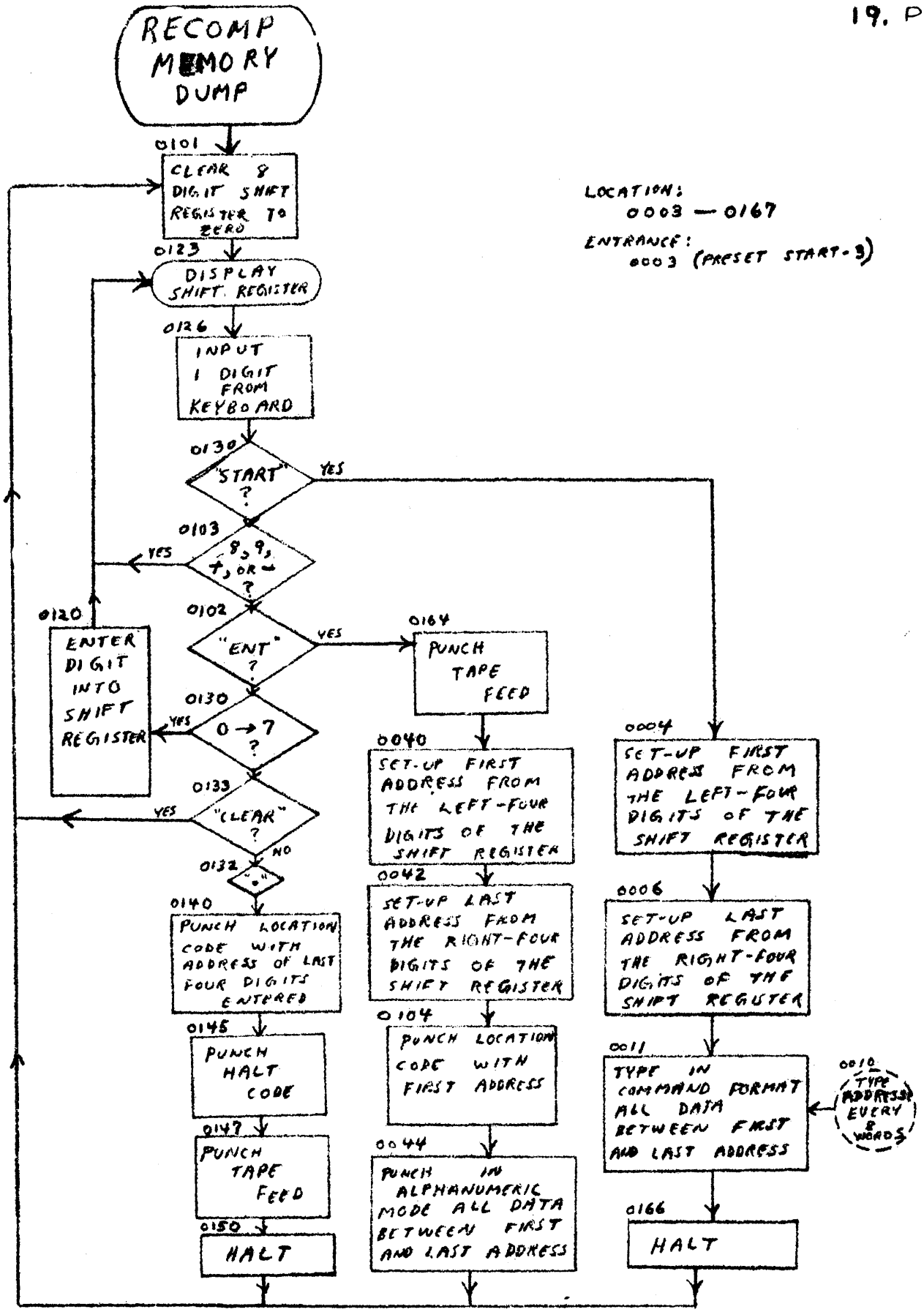
B. Punch Memory Contents:

If the "ent" key is depressed, the data between the left and right address showing on the display tubes at that time are punched in alphanumeric format along with a leading length of blank tape leader and a location code coresponding to the left address location.

C. Punched Tape Termination:

After all desired areas of memory are punched on tape, the tape is terminated by pressing the key marked "." on the keyboard. This will set up a new location code corresponding to the right address group shown on the display tubes, punch a HALT code on tape, (or if sense switch D is down, a START code,) punch a blank tape trailer, and mark the end of the tape with an E punched on the tape.

The memory dump routine may be used to give a listing of any area of the program by using the addresses shown on the flow charts or the routine may be used to punch additional copies of the program. When punching copies of the program, remember that locations within the memory dump portion of the program are changing. Therefore, the tape will not verify with the memory. This can be partially taken into account by punching the area 0000 to 0177 last (memory dump routine) and then when the verify light does come on, most of the tape should already be verified. The verify error light should never come on however after first filling the tape that was punched.



LOCATION:
0003 — 0167

ENTRANCE:
0003 (PRESET START-S)

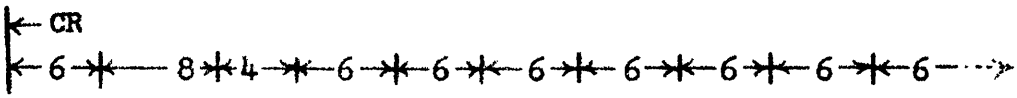
RECOMP MEMORY DUMP

9. Summary:

Program Storage:

5000 to 5777 (program and storage)
0270 to 0437 (special data output)
3000 to 3137 (data input routine)
0500 to 0517 (alphanumeric output)
0000 to 0177 (memory dump and preset start locations)

TAB Settings:



Preset Start Buttons:

1. Time of explosion
2. Position readings (and position report)
3. Intensity Level(s)

Other entry locations:

5240.0 ---- Position Report
5555.0 ---- Intensity Saftey Level
0101.0 ---- Memory Dump

Sense Switches:

B ---- Not used
C ---- (when on) will print time when intensity level is safe.
D ---- (when on) will cause a memory dump tape to be terminated with a "start" instead of a "halt" code.

For copies of this demonstration tape, description of the program, or additional information, contact the following:

Commanding Officer
U S A S R D L
Fort Monmouth, N. J.
attn: SIGFM/EL-NPE, Mr. L. Halprin