Accumulator Number	1	2	3	4	5	6	7	8 (and 9)	10 (and 9)	11 and 12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Digit Storage Position	6	6	6	7	7	7	7	7	10	—	0		10		—	*	7	—	5	8										
Decimal Point of Accumulator	3.7	3.7	4.6	3.7	3.7	C.10	—	Variable	Variable	—	Variable		Variable		—	8	Variable	—	4.5	Variable										
Addition Times Reported	1	1	1	1	1	1	1	Variable	Variable	Multiplier	Left hand Factor		Cont. Hand Product Accumulator		Master Programmer	Accumulator	Argument Accumulator	Function Table	Accumulator	Storage	NOT USED	Divider	NOT USED	NOT USED	Constant Transmitter (Push Keys)	Constant Transmitter (Switch)	Printer Accumulator	Printer Accumulator	Printer Accumulator	Printer Accumulator
Program Line Used	5-1	5-2	5-3	5-4																										
Initial Conditions Set	0-1	0-2	0-11	0-3	0-4	0-5	0-6	0-7	0-8	0-9	0-10	1-1	1-11	1-2	2-11	1-3	1-4	1-5	1-6	1-7	1-8	1-9	6-1	1-10	2-1	2-2	2-3	2-4	2-5	2-6
Accumulator	$\dot{x}$	x_1	y	$\dot{y}$	$\dot{y}_1$	F	F_1																							
	$0 \le \dot{x} < 10^3$		$0 < y < 10^4$	$0 < \dot{y} < 10^3$		$0.1 < F < 0.4$																							

Accumulator Number	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Digit Storage Position	6	6	7	7	7	7	7	7	10	—		0		10		—	*	7	—	5	8										
Decimal Point of Accumulator	3.7	4.6	3.7	3.7	C.10	—	Variable	Variable	Variable	—		Variable		Variable		—	8	Variable	—	4.5	Variable										
Addition Times Reported	1	1	1	1	1	1	Variable	Variable	Variable	Multiplier		Left hand Factor		Cont. Hand Product Accumulator		Master Programmer	Accumulator	Argument Accumulator	Function Table	Accumulator	Storage	NOT USED	Divider	NOT USED	NOT USED	Constant Transmitter (Push Keys)	Constant Transmitter (Switch)	Printer Accumulator	Printer Accumulator	Printer Accumulator	Printer Accumulator
Program Line Used	1-4	1-5	1-6	1-7	1-8	1-9	6-1	1-10	2-1	2-2	2-3	2-4	2-5	2-6	2-7	2-8	2-9	2-10	3-1	3-2	3-3	3-4	3-11	3-8	3-6	3-7	3-8	3-9	3-10	4-1	4-2
Accumulator	$Y_1[4.2]$																													

Accumulator Number	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Digit Storage Position	6	7	7	7	7	7	7	10	—		0		10		—	*	7	—	5	8										
Decimal Point of Accumulator	3.7	3.7	3.7	C.10	—	Variable	Variable	Variable	—		Variable		Variable		—	8	Variable	—	4.5	Variable										
Addition Times Reported	1	1	1	1	1	Variable	Variable	Variable	Multiplier		Left hand Factor		Cont. Hand Product Accumulator		Master Programmer	Accumulator	Argument Accumulator	Function Table	Accumulator	Storage	NOT USED	Divider	NOT USED	NOT USED	Constant Transmitter (Push Keys)	Constant Transmitter (Switch)	Printer Accumulator	Printer Accumulator	Printer Accumulator	Printer Accumulator
Program Line Used	2-11	1-2	1-4	1-5	1-6	1-7	1-8	1-9	2-1	2-2	2-3	2-4	2-5	2-6	2-7	2-8	2-9	2-10	3-1	3-2	3-3	3-4	3-11	3-8	3-6	3-7	3-8	3-9	3-10	4-1	4-2
Accumulator	$Y_1[4.2]$																													

CODE

- ○ Transmit from addend output to accumulator indicated.
- Ⓢ Transmit from subtrahend output to accumulator indicated.
- Ⓜ Transmit from addend output n times to accumulator indicated.
- (m) Transmit from subtrahend output n times to accumulator indicated.
- [n] Indicates that incoming number is shifted n places to the left before being placed in accumulator. (A negative number indicates a shift to the right.)
- [n,p] Indicates number of digits before and after decimal point, respectively.
- ∿ Clear contents of accumulator to zero.
- ◈ Indicates the number of multiplier digits used in multiplication.
- f(x) Function table transmits the value of the function corresponding to the first two places of the argument, i.e. corresponding to the 4th + 5th places in the argument accumulator.
- f(x+1) Function table transmits the value of the function corresponding to the first two places of the argument plus 1.
- [21] Indicates a special adaptor which deletes all but the 6th + 7th places of the argument and shifts them five places to the left
- ◇ - - - Indicates multiplication
- c. Indicates correction pulse must be put in.

DIFFERENCE EQUATIONS
(HEUN METHOD)

NOTATION:

Values at beginning of integration step:
t_0 x_0 $\dot{x}_0$ y_0 $\dot{y}_0$ F_0 G_0 E_0

Intermediate values of variables
t_1 $\dot{x}_1$ y_1 $\dot{y}_1$ F_1 G_1 E_1

Values at end of integration steps:
t_2 x_2 $\dot{x}_2$ y_2 $\dot{y}_2$ F_2

VALUES OF CONSTANTS:

- $\frac{\Delta t}{2}$ = 0.01 seconds
- b = 9.86 $\times 10^{-8}$ meters
- h = 98.736 $\times 10^{-8}$ meters
- H_0 = 1
- c = 2.5 to 5.0
- F_0 = $\frac{1}{2}$

RANGE OF VARIABLES

- $0 < \dot{x} < 10^3$ meters
- $0 < y < 10^4$ meters
- $0 < \dot{x} < 10^3$ meters/second
- $0 < \dot{y} < 10^3$ meters/second
- $0 < (\dot{x}^2+\dot{y}^2) < 5 \times 10^6$
- $0.1 < F < 0.4$
- $0 < G < 0.40$

THE EQUATIONS

$$t_2 = t_0 + 2\left(\frac{\Delta t}{2}\right)$$

$$\frac{\Delta \dot{x}}{2} = -(E, \dot{y}_1 + g)\frac{\Delta t}{2} \qquad \dot{x}_1 = \dot{x}_0 + 2\left(\frac{\Delta \dot{x}}{2}\right)$$

$$\frac{\Delta \dot{y}}{2} = -(E, \dot{y}_1 + g)\frac{\Delta t}{2} \qquad \dot{y}_2 = \dot{y}_0 + \frac{\Delta \dot{y}}{2} + \frac{\Delta \dot{y}}{2}$$

$$\frac{\Delta x}{2} = (E, \dot{x}_1)\frac{\Delta t}{2} \qquad x_1 = x_0 + 2\left(\frac{\Delta x}{2}\right)$$

$$\frac{\Delta x}{2} = (E, \dot{x})\frac{\Delta t}{2} \qquad x_2 = x_0 + \frac{\Delta x}{2} + \frac{\Delta x}{2}$$

$$\frac{\Delta F}{2} = -(hF, \dot{x})\frac{\Delta t}{2} \qquad F_1 = F_0 + 2\left(\frac{\Delta F}{2}\right)$$

$$\frac{\Delta F}{2} = -(hF, \dot{y})\frac{\Delta t}{2} \qquad F_2 = F_0 + \frac{\Delta F}{2} + \frac{\Delta F}{2}$$

$$\frac{\Delta y}{2} = \dot{y}_1\frac{\Delta t}{2} \qquad y_1 = y_0 + 2\left(\frac{\Delta y}{2}\right)$$

$$\frac{\Delta y}{2} = \dot{y}_1\frac{\Delta t}{2} \qquad y_2 = y_0 + \frac{\Delta y}{2} + \frac{\Delta y}{2}$$

$$\frac{\Delta x}{2} = \dot{x}_1\frac{\Delta t}{2} \qquad x_2 = x_0 + \frac{\Delta x}{2} + \frac{\Delta x}{2}$$

$$\frac{\Delta x}{2} = \dot{x}_1\frac{\Delta t}{2} \qquad t_2 = t_0 + \Delta t$$

The range of the argument of G is extended by a factor of 8 to make full use of the range of the ENIAC function table. Hence:

$$\theta_0 = G\left[8\left(\dot{x}_0^2 + \dot{y}_0^2\right)(1 - by_0)^2\right] \qquad E_0 = F_0 G_0$$

$$G_1 = G\left[8\left(\dot{x}_1^2 + \dot{y}_1^2\right)(1 - by_1)^2\right]$$

Linear interpolation is performed to get the value for G. Hence:

$$G = F(a) + \Delta a\,[F(a+1) - F(a)]$$

where, a is the first two places of the argument, and Δa, the third and fourth places.

PLAINTIFF'S EXHIBIT
U.S. Dist. Court
S.D. of N.Y.
MAR 6 1962
#15-20 (5)

MOORE SCHOOL OF ELECTRICAL ENGINEERING
UNIVERSITY OF PENNSYLVANIA
SETUP OF EXTERIOR BALLISTICS

Drawn by R.A.B.