~~SECRET~~ EXTRACT A67/A.C. MAN./3

SNAP-UP CLIMB MANOEUVRES FOR THE CF-105

T. F. Potts ~~SECRET~~ June 1957

A. V. ROE CANADA LIMITED
MALTON ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT CF-105

REPORT No. EXTRACT A67/A.C. MANOEUVRES/3

FILE No.

No. OF SHEETS

TITLE

~~SECRET~~

SNAP-UP CLIMB MANOEUVRES
FOR THE CF-105

PREPARED BY T. F. Potts T.F.P. DATE June 1957

CHECKED BY R. R. Carley DATE June 1957

SUPERVISED BY DATE

APPROVED BY DATE

ISSUE No.	REVISION No.	REVISED BY	APPROVED BY	DATE	REMARKS

FORM 1316A

AVRO AIRCRAFT LIMITED
MALTON · ONTARIO
TECHNICAL DEPARTMENT

REPORT NO. Extract A67/A.C. Man./3

SHEET NO.

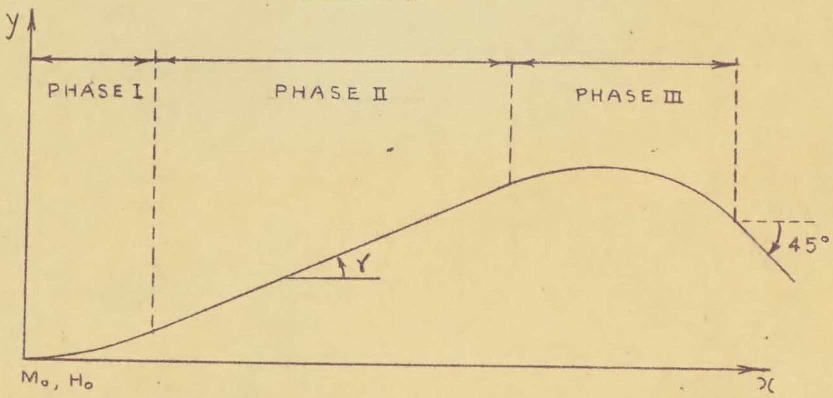
AIRCRAFT:		PREPARED BY	DATE
CF-105	SECRET	T. F. Potts	June 1957
		CHECKED BY	DATE
		R. R. Carley	June 1957

<u>INDEX</u> (Continued)

This report continues work begun in A47/A.C. Manoeuvres/2 on Dynamic Manoeuvres for the CF-105

DESCRIPTION OF SNAP-UP CLIMB MANOEUVRE:-

FIG. 1



During Phase I the aircraft is snapped-up from initial level flight at M_o, H_o to angle of climb γ. During Phase II γ is maintained constant. Total time for phases I and II is twenty seconds. At the end of Phase II, the aircraft is rolled through 180° and then during Phase III is pulled down until it is diving at 45° to the horizontal.

CASES STUDIED:-

Initial altitudes and Mach numbers, and commanded angles of climb studied are as follows:-

H_o = 36,000 ft.	$M_o = 2.0$	$\gamma_c = 10^\circ$	20°	30°
	$M_o = 1.5$	$\gamma_c = 10^\circ$	20°	30°
H_o = 50,000 ft.	$M_o = 2.0$	$\gamma_c = 10^\circ$	20°	30°
	$M_o = 1.5$	$\gamma_c = 10^\circ$	20°	30°

Solutions are presented as curves of y vs. x with time intervals marked along the curve, and M, n, and γ against time. A hand-calculated check solution, assuming instantaneous responses, is included for comparison. Solutions are valid only for $M \geq 1.0$ and $H \geq 36{,}000$ ft.

GEOMETRY AND EQUATIONS OF MOTION:-

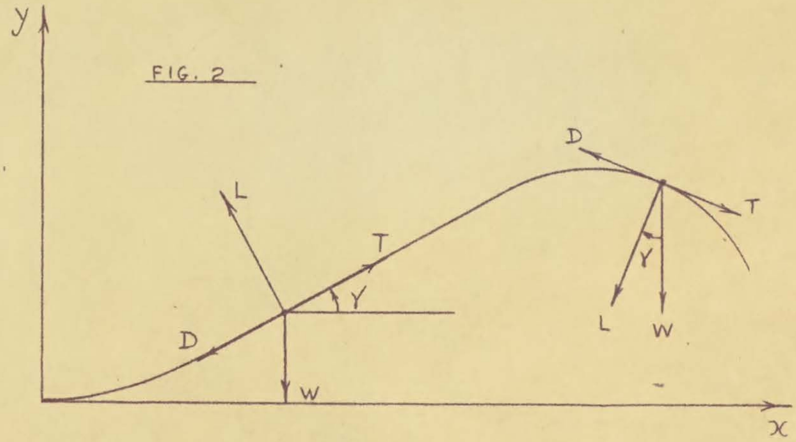


FIG. 2

(1)... $\frac{dM}{dt} = \frac{g}{aW}\left[2F_N^* \cdot \frac{F_N}{F_N^*} - P\left(K_1\left(\frac{n}{p} \cdot W \times 10^{-4} - 2.11\right)^2 + \frac{D_{MIN}}{p}\right)\right] - \frac{g}{a}\sin\gamma$

(2)... $\frac{d\gamma}{dt} = \frac{57.3\,g}{aM}\left[P \cdot \frac{n}{p}\sin\phi - \cos\gamma\right]$

(3)... $\frac{dx}{dt} = aM\cos\gamma$

(4)... $\frac{dy}{dt} = aM\sin\gamma$

Where ϕ is the roll angle ($\phi = \pm 90°$)

The angle of attack is omitted.

$a = 968.5$ FT/sec.
$W = 53{,}000$ pounds.

FORM 1318A

In the expression $2F_N^* \cdot \frac{F_N}{F_N^*}$, $2F_N^*$ and $\frac{F_N}{F_N^*}$ are functions of Mach number and altitude respectively, whose product yields maximum thrust for two PS - 13 engines with afterburners.

The values of $2F_N$ given by this mechanization are everywhere within $2\frac{1}{2}\%$ of the values given by the carpet, and over most of the range the error is considerably less than this value.

The expression $p(K_1 (\frac{n}{p} \cdot W \times 10^{-4} - 2.11)^2 + \frac{D_{MIN}}{p}$ is the mechanization for the carpet of total trimmed drag with 4° up-aileron deflection. The values of drag given by this mechanization are everywhere within 2% of the values given by the carpet, and over most of the range the error is considerably less than this value. Although the ailerons will only be deflected above 45,000 ft. and the carpet for undeflected ailerons should be used below this altitude, lack of computing equipment makes this impossible at the moment. The one set of data was therefore used throughout.

Normal acceleration 'n' is obtained from the product $p \cdot (\frac{n}{p})_{MAX}$ where $(\frac{n}{p})_{MAX}$ is a function of Mach number. Maximum 'n' is limited by buffet for $M < 1.08$ and by available trim for $M > 1.08$. Hinge moment limitation is not considered serious at these altitudes and Mach numbers, and its effects have been ignored. In the simulation, the value of n_{MAX} has been limited to 5.5 'g', corresponding to the damper command limit.

A lag of $\frac{1}{1 + .5S}$ has been introduced in $\frac{n}{p}$ in the simulation to allow for the response of the aircraft in pitch. No allowance has been made, however, for response time in roll. In locking on to the commanded climb angle, it has been assumed that the aircraft would be flown so as to overshoot the value of 'n' required for climb at this angle by about $\frac{1}{3}$ 'g'.

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TECHNICAL DEPARTMENT

AIRCRAFT:		REPORT No. EXTRACT A67/A.C. MAN./3	
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		T. F. Potts	June'57
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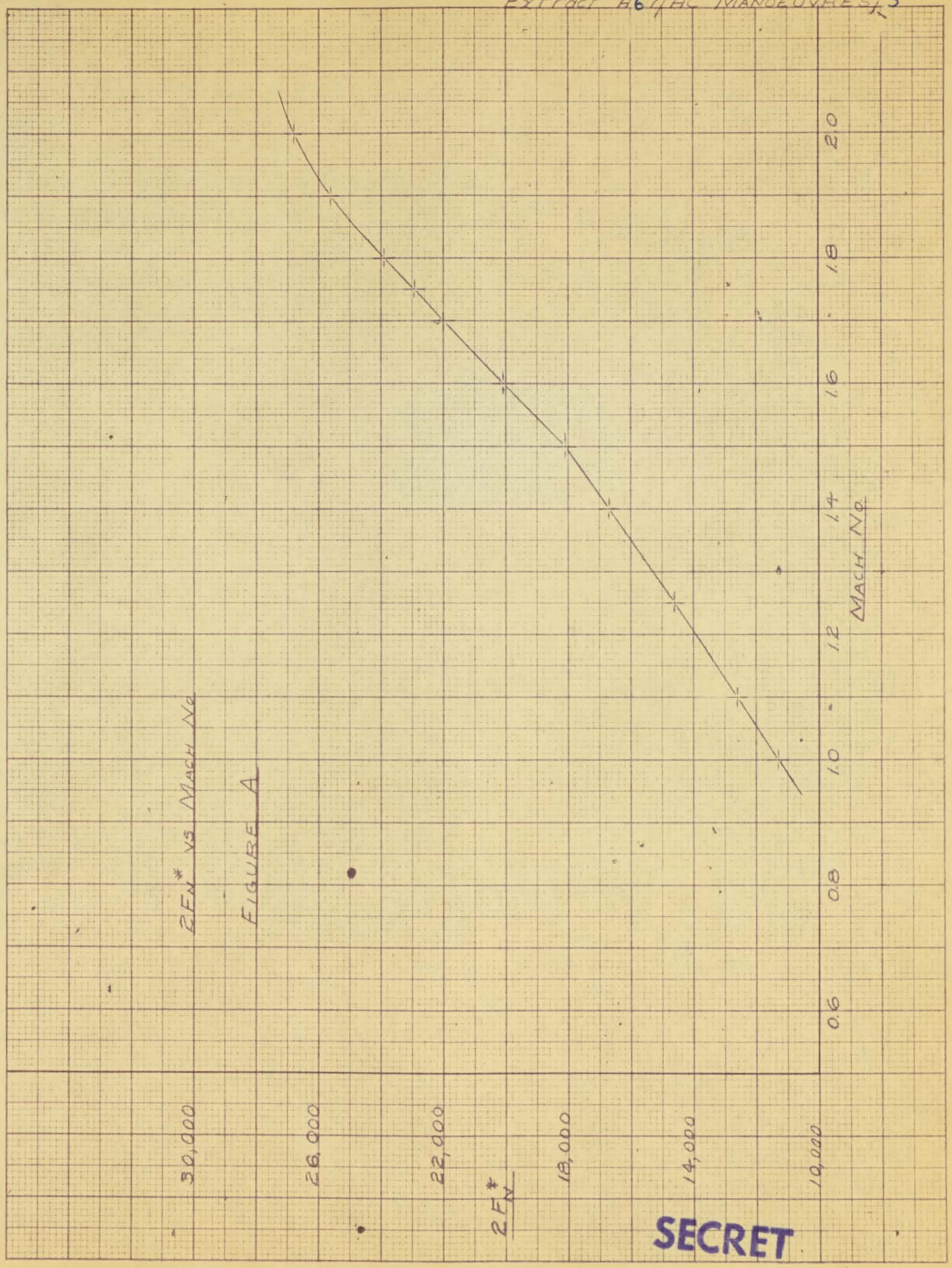
		R. R. Carley	June'57

The functions $2F_N^*$, $\frac{F_N}{F_N^*}$, $\frac{D_{MIN}}{p}$, $\mathbf{p}$, K_1 and $\frac{n}{p}$ are presented in Figs. A to F. The data for these functions was obtained from Messrs. J. Cohen and T. Roberts of Performance Group.

FORM 1319A

Extract A67/AC MANOEUVRES/3



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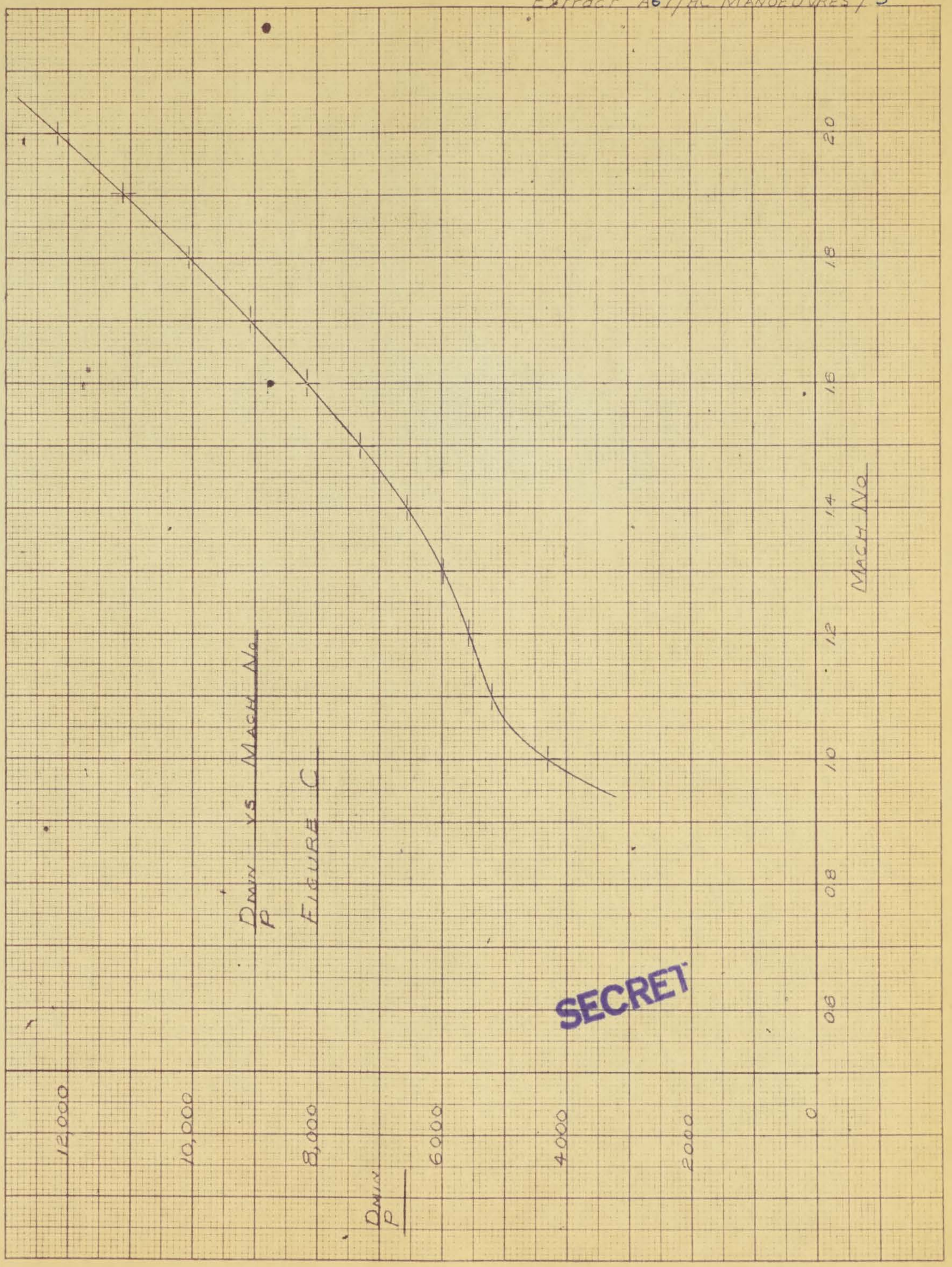
Extract A67/RC Manoeuvres/3



$\frac{D_{MIN}}{P}$ vs Mach No

Figure C

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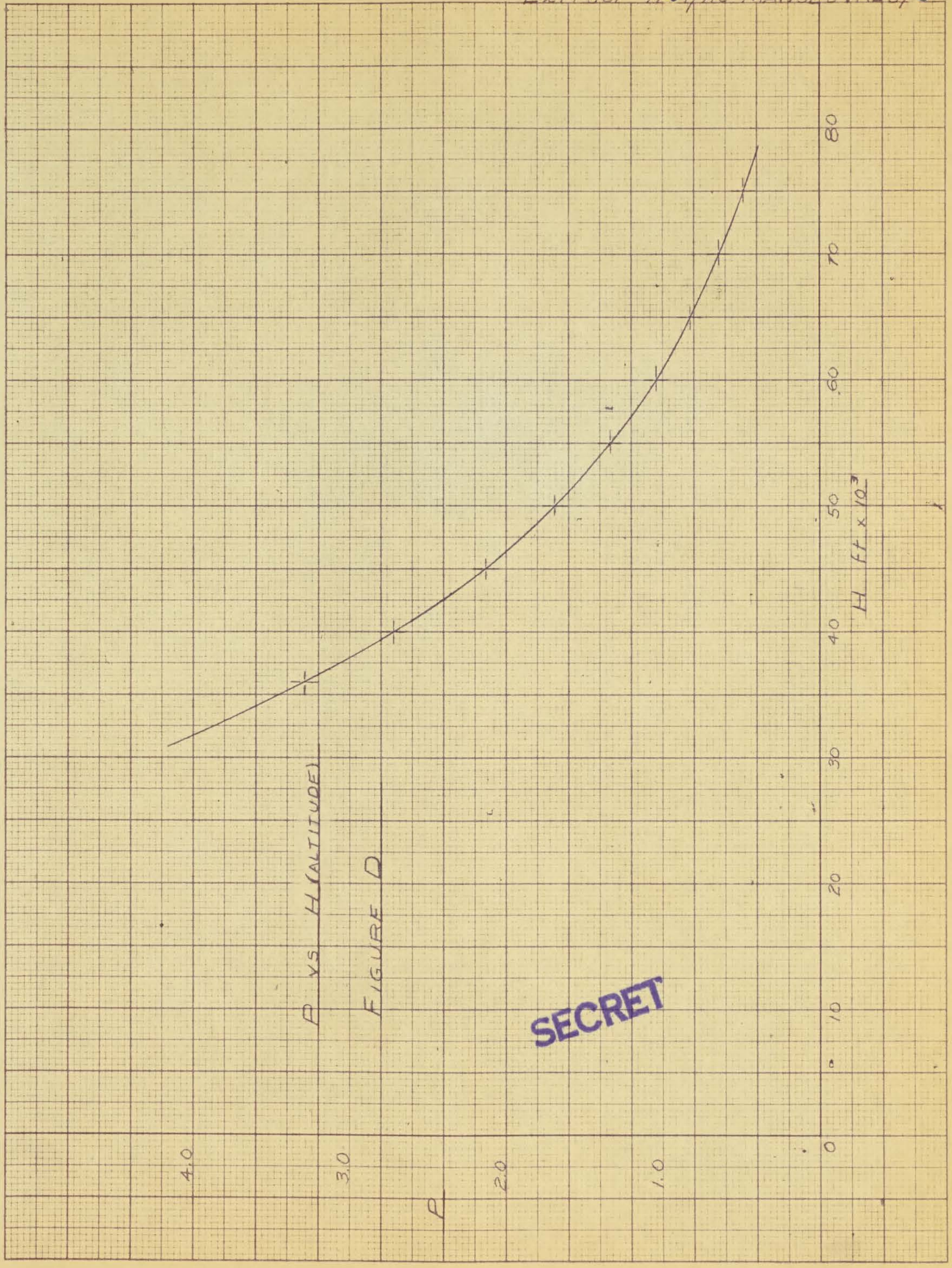
Extract A67/AC MANOEUVRES/3



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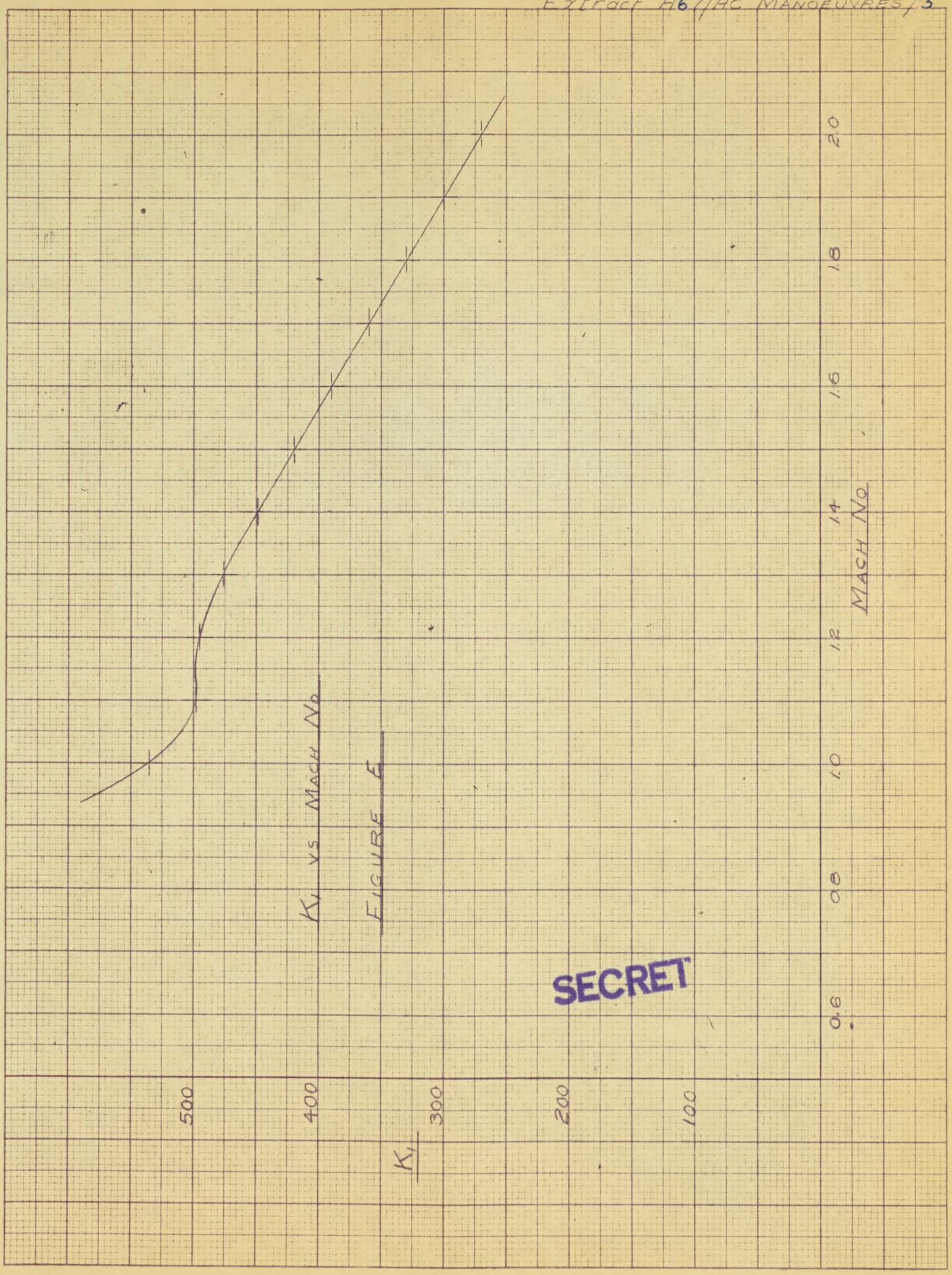
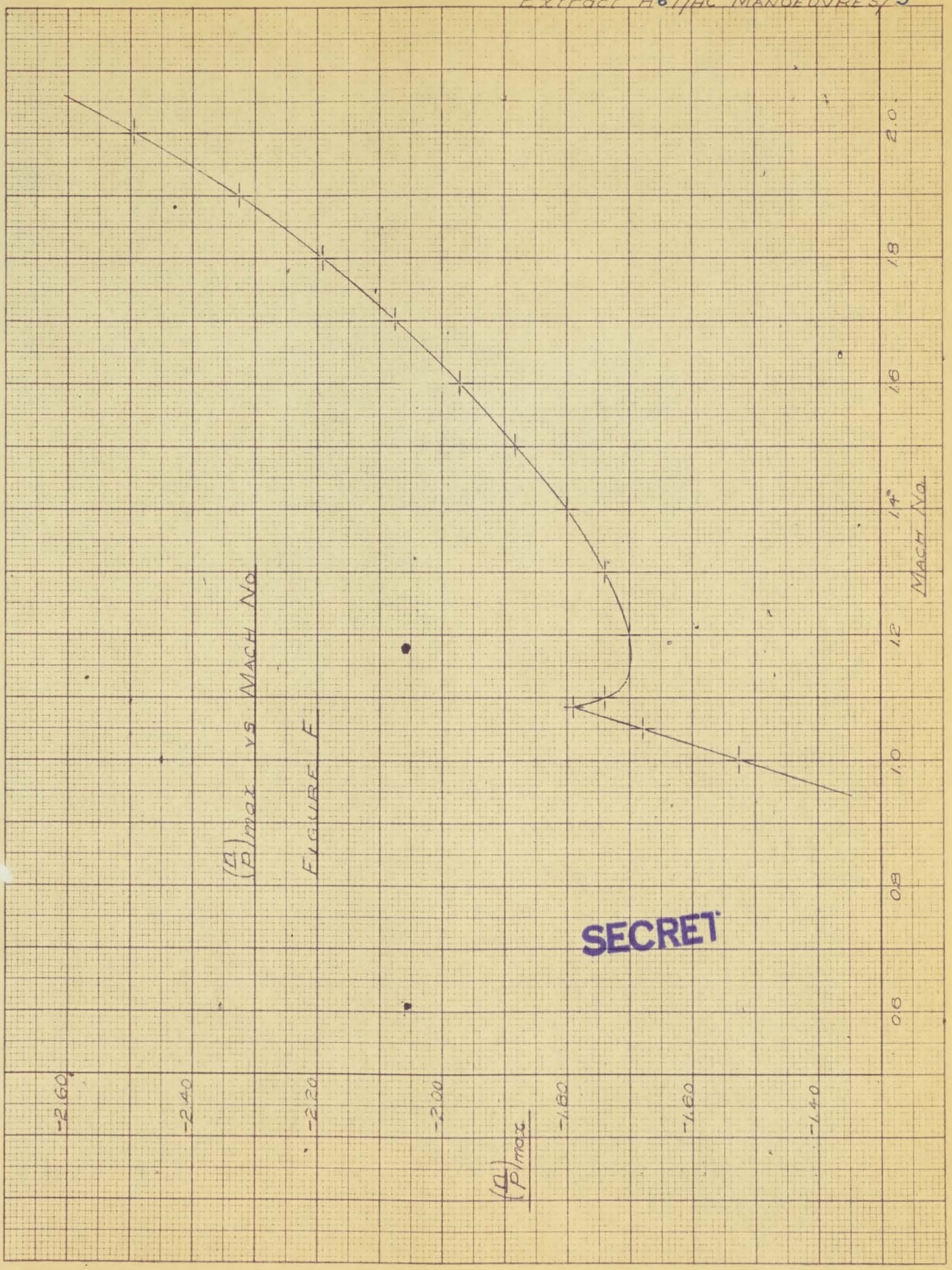


G9-12
10 X 10 TO THE 1/2 INCH
MADE IN CANADA

Extract A67/AC MANOEUVRES/3



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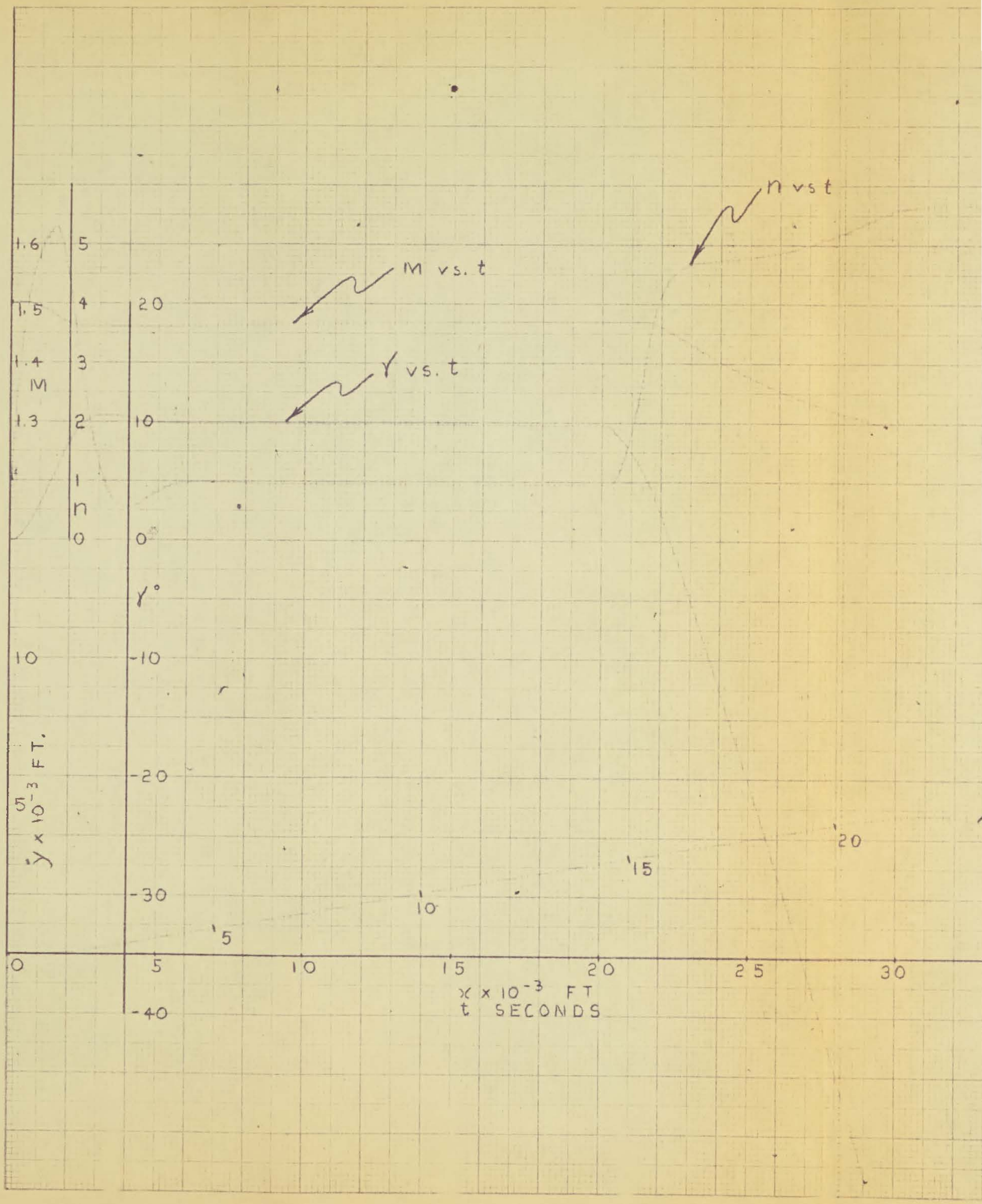
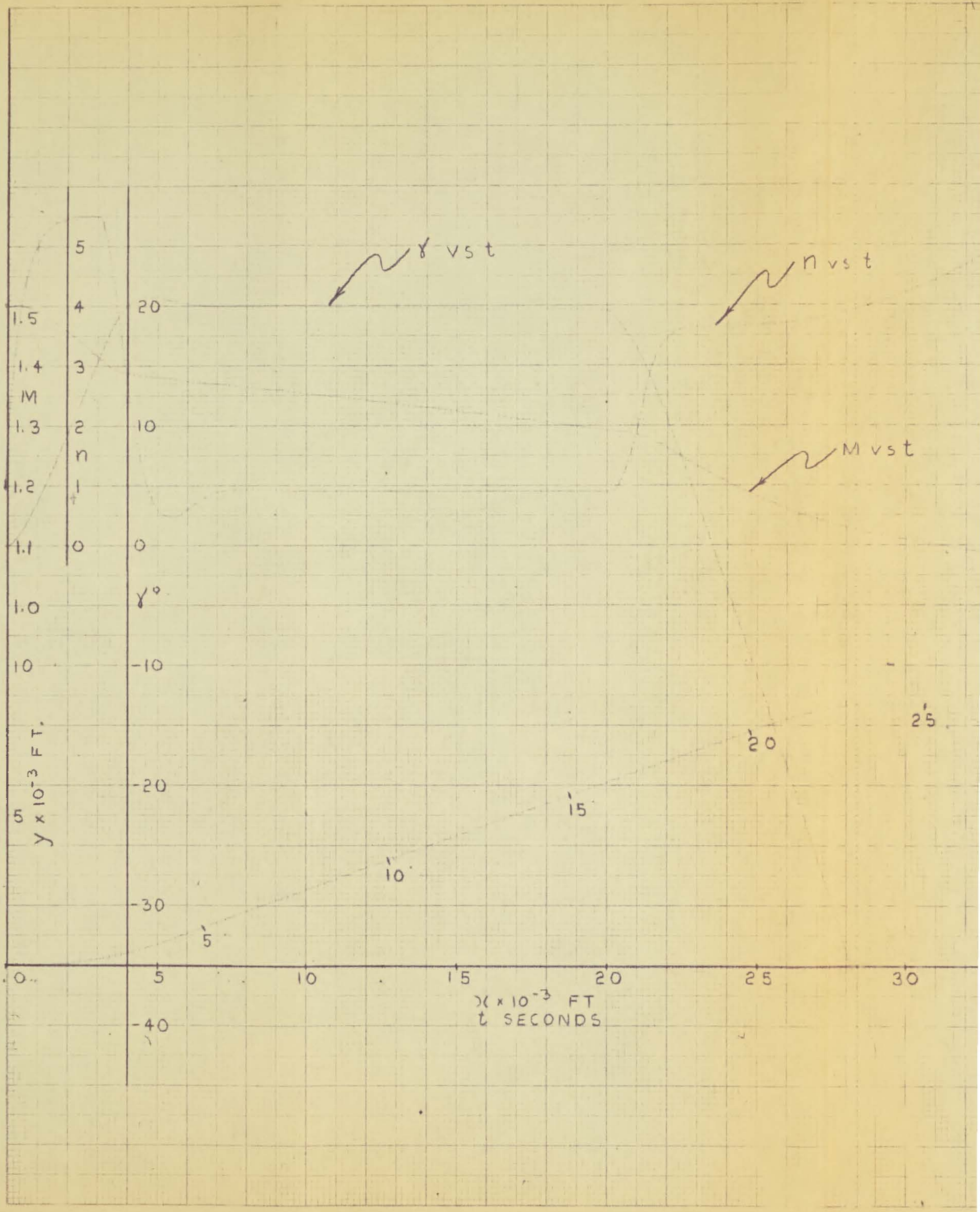
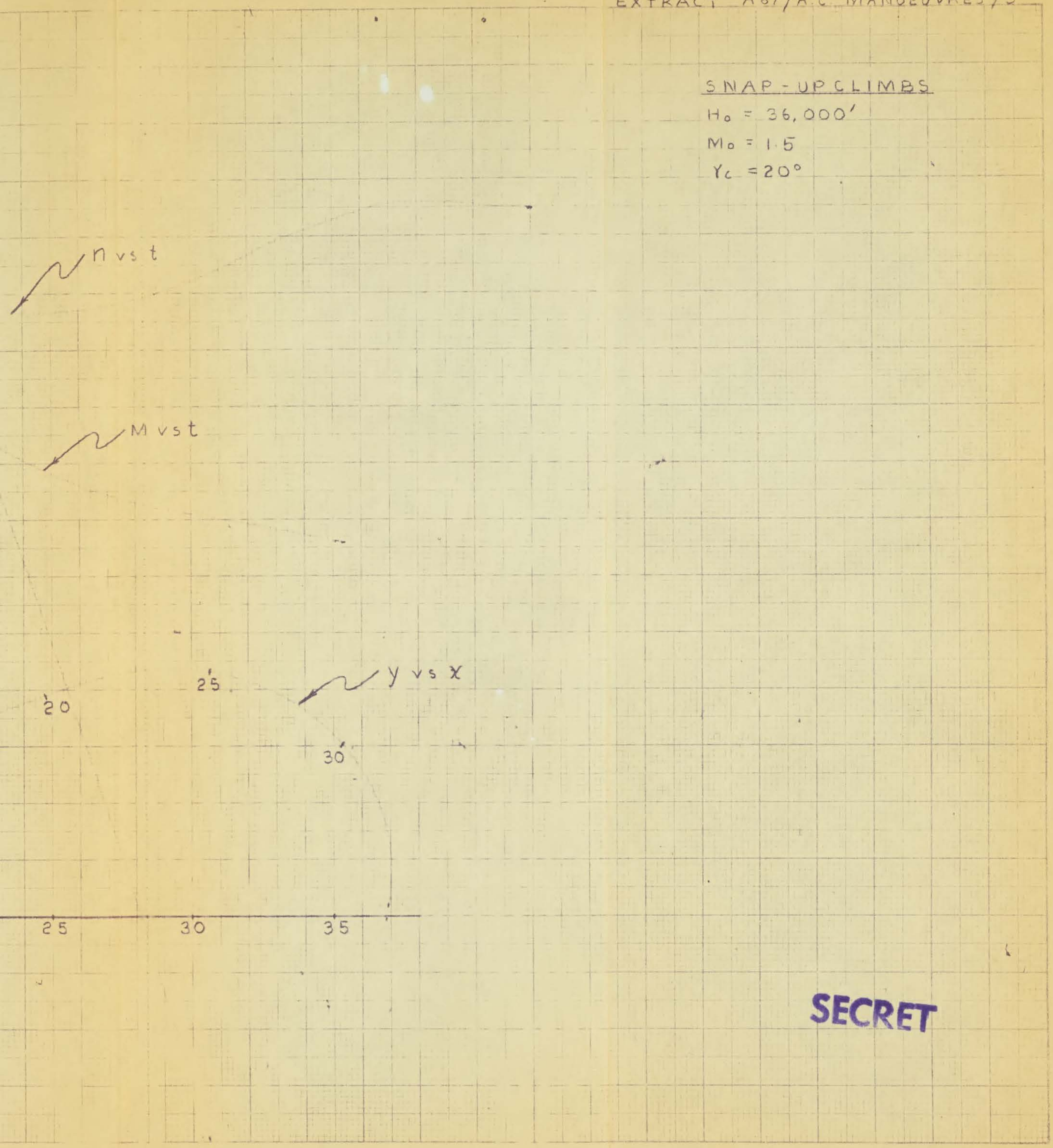
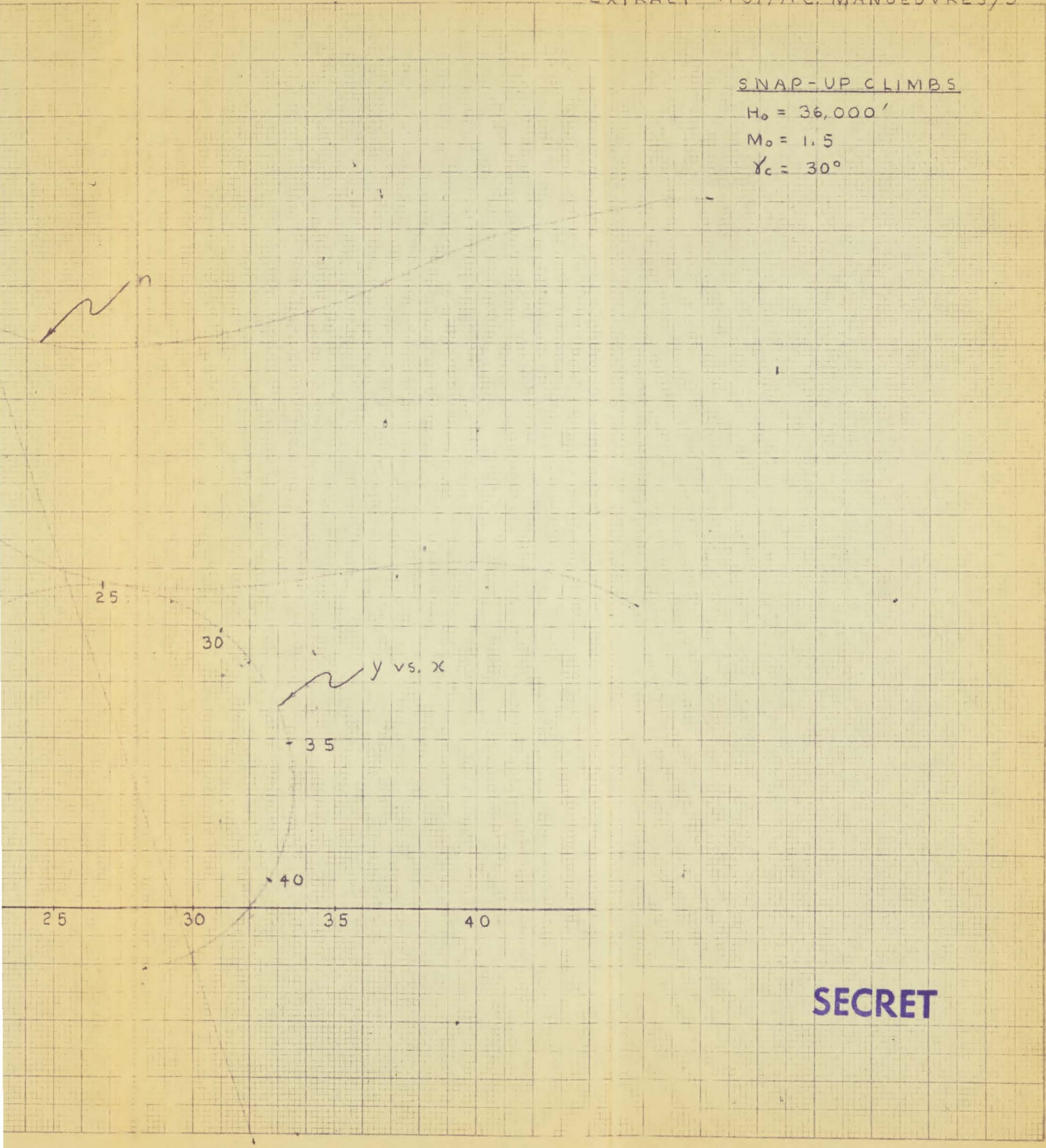

n vs t
M vs. t
γ vs. t
M
1.3
1.4
1.5
1.6
n
0
1
2
3
4
5
γ°
-40
-30
-20
-10
0
10
20
y × 10⁻³ FT.
5
10
x × 10⁻³ FT
t SECONDS
0
5
10
15
20
25
30

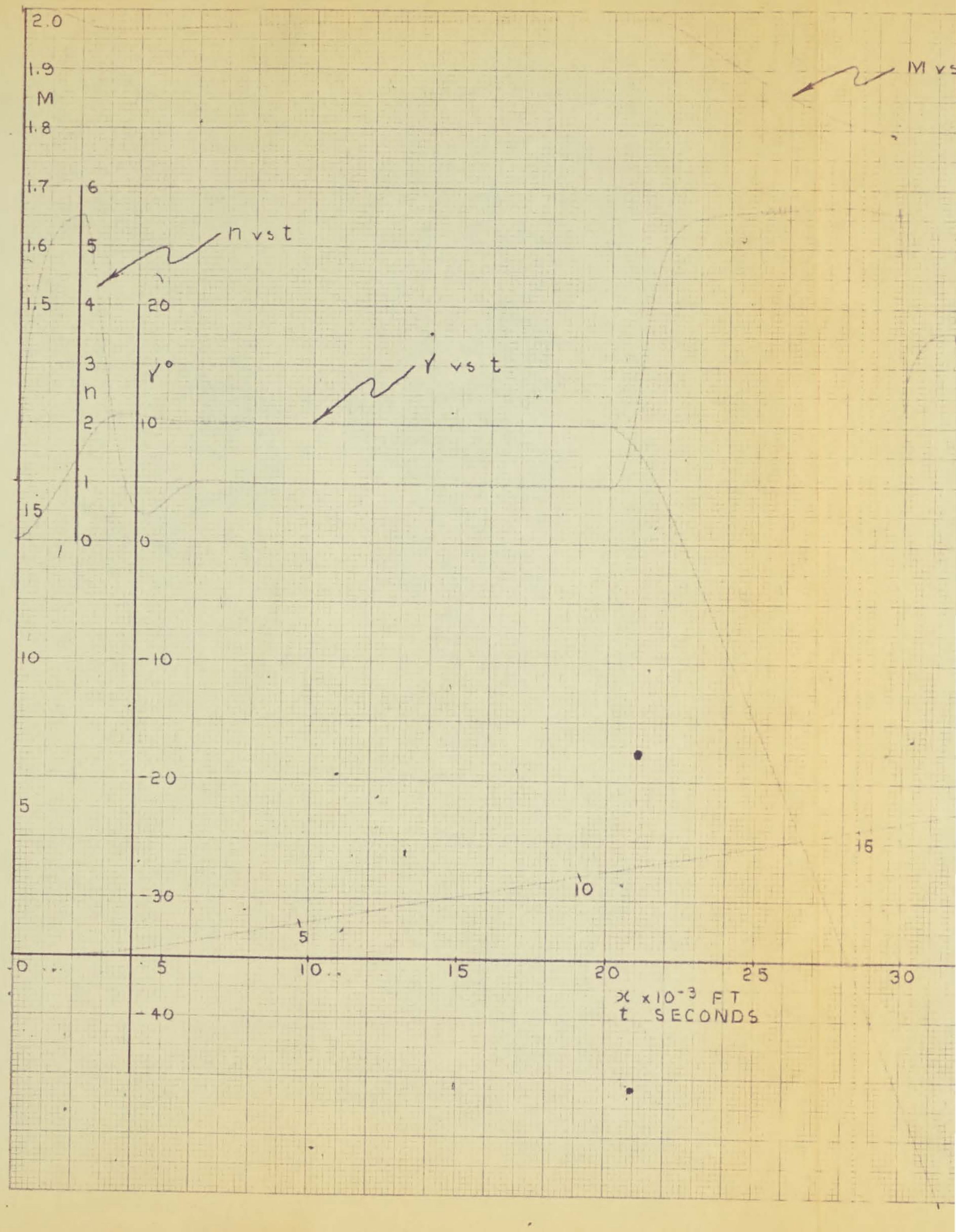


γ vs t
n vs t
M vs t
M
n
γ°
y x 10^-3 FT.
x x 10^-3 FT
t SECONDS

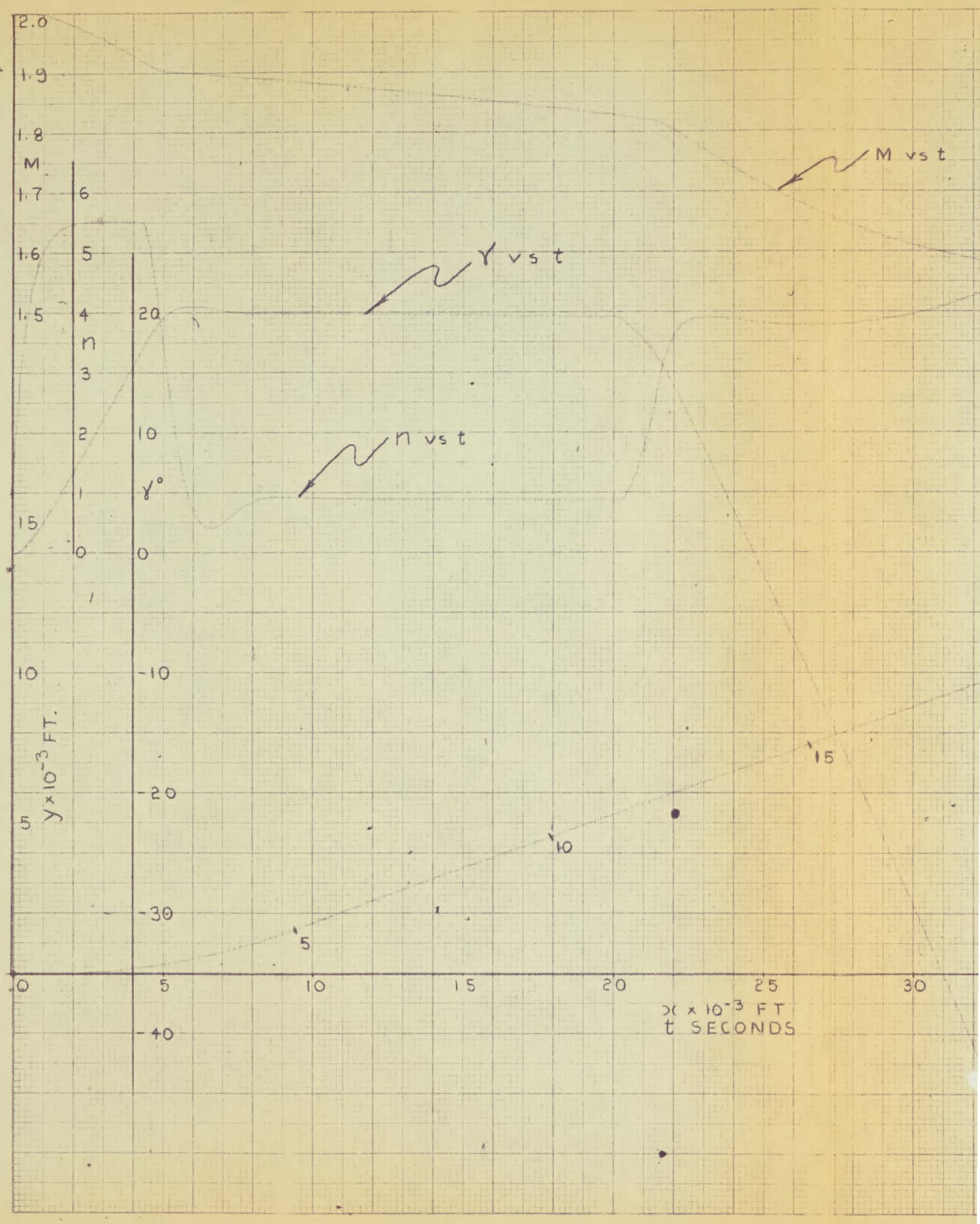
EXTRACT A67/A.C. MANOEUVRES/3



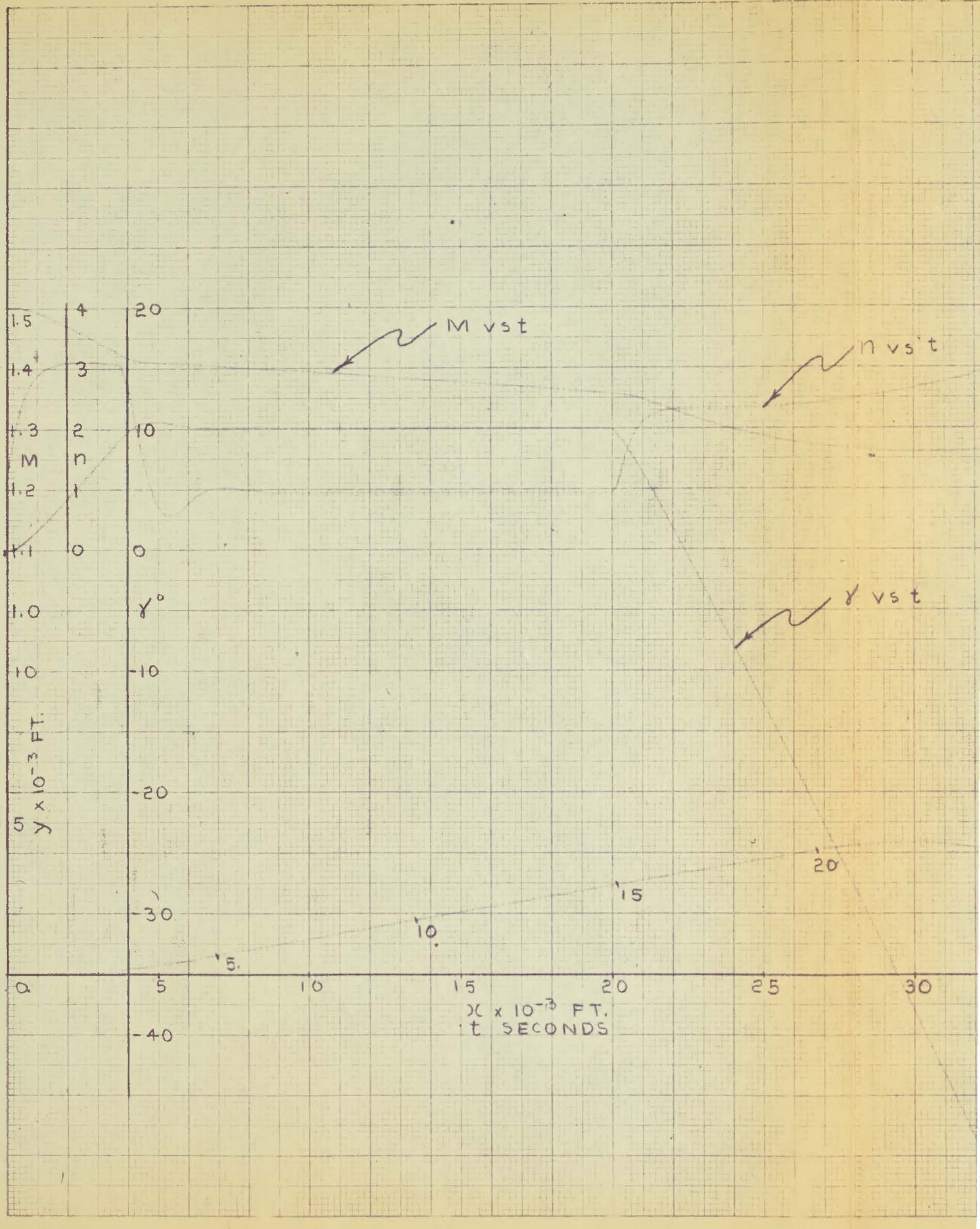

SNAP-UP CLIMBS
$H_o = 36{,}000'$
$M_o = 1.5$
$\gamma_c = 30°$
n
y vs. x
25
30
35
40
25
30
35
40



M vs
n vs t
γ vs t
M
n
γ°
x × 10⁻³ FT
t SECONDS



M vs t
γ vs t
n vs t
M
n
γ°
y × 10⁻³ FT.
x × 10⁻³ FT
t SECONDS
2.0
1.9
1.8
1.7
1.6
1.5
6
5
4
3
2
1
0
20
10
0
-10
-20
-30
-40
15
10
5
0
5
10
15
20
25
30


M vs t
n vs t
γ vs t
M
n
γ°
y x 10⁻³ FT.
x x 10⁻³ FT.
t SECONDS
1.5
1.4
1.3
1.2
1.1
1.0
4
3
2
1
0
20
10
0
-10
-20
-30
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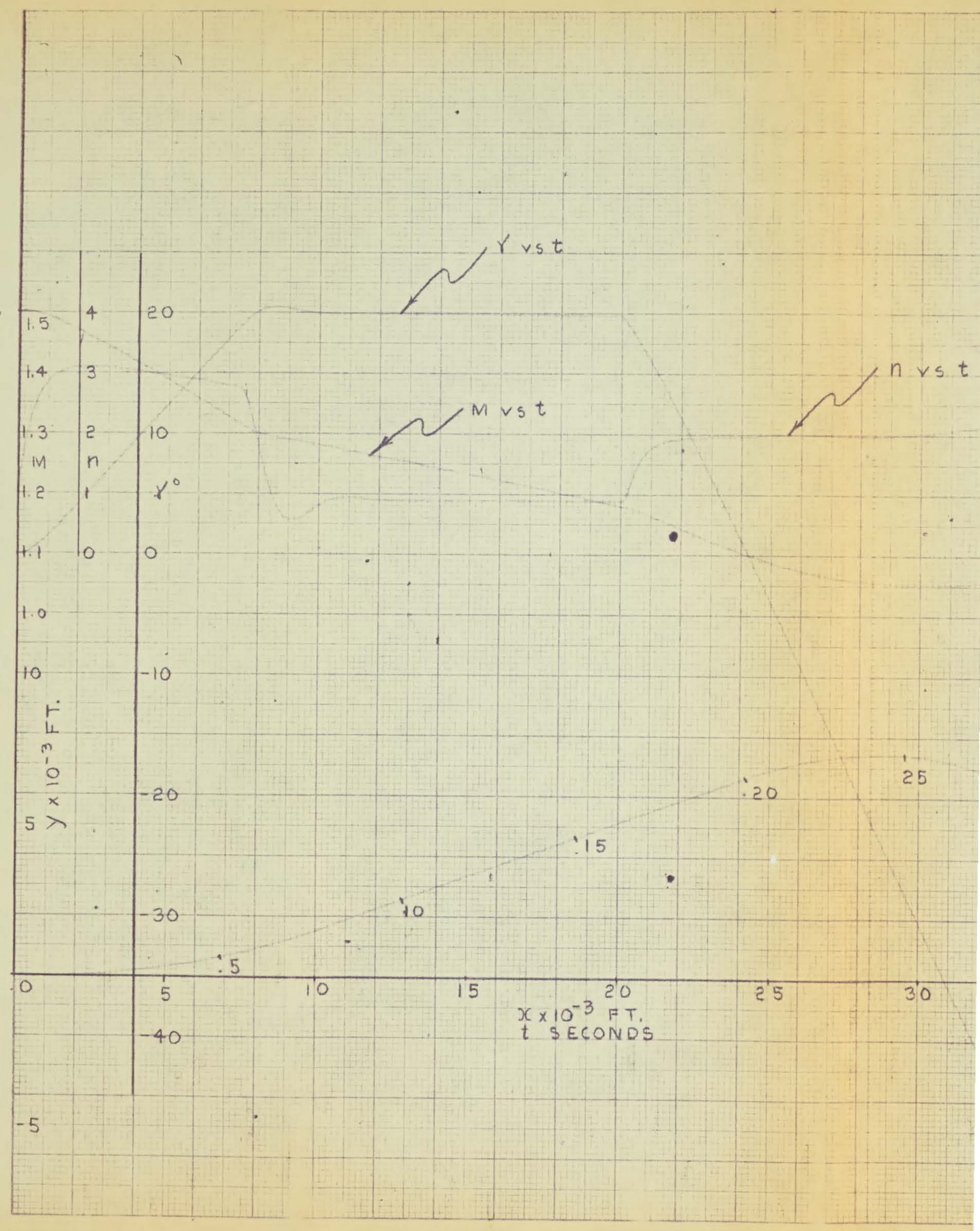
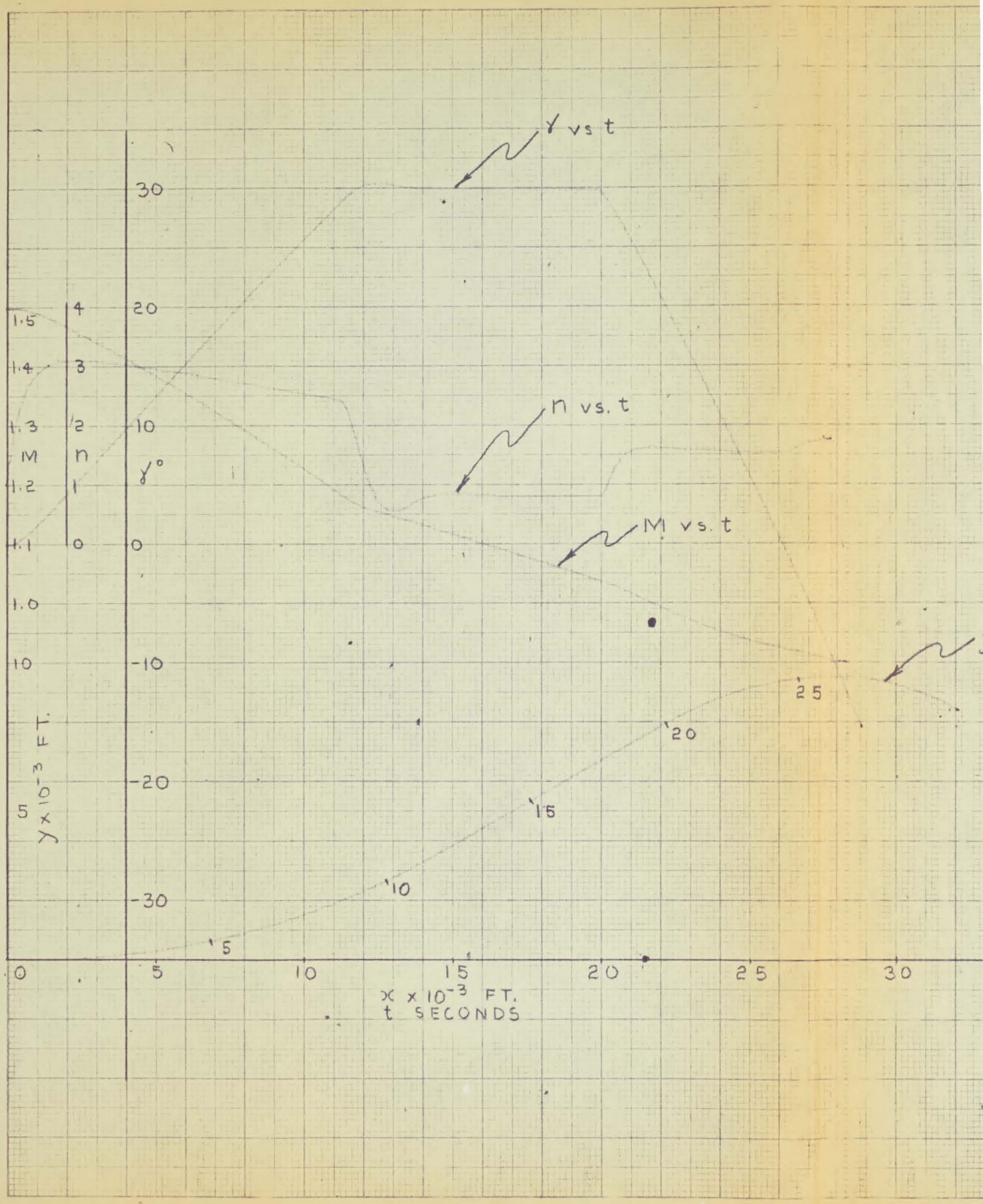
25
30
5.
10
15
20

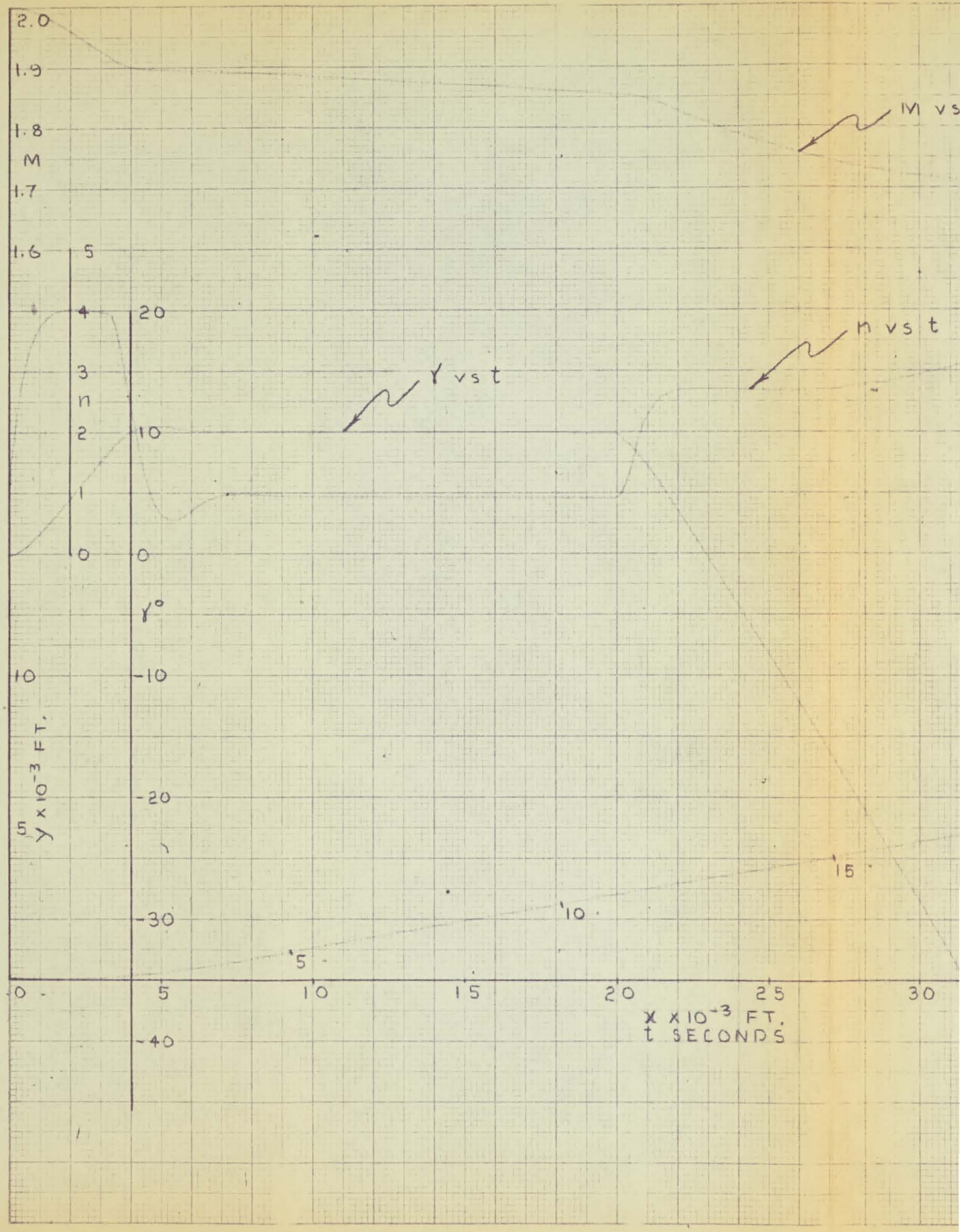


γ vs t
n vs t
M vs t
M
n
γ°
y x 10⁻³ FT.
X x 10⁻³ FT.
t SECONDS

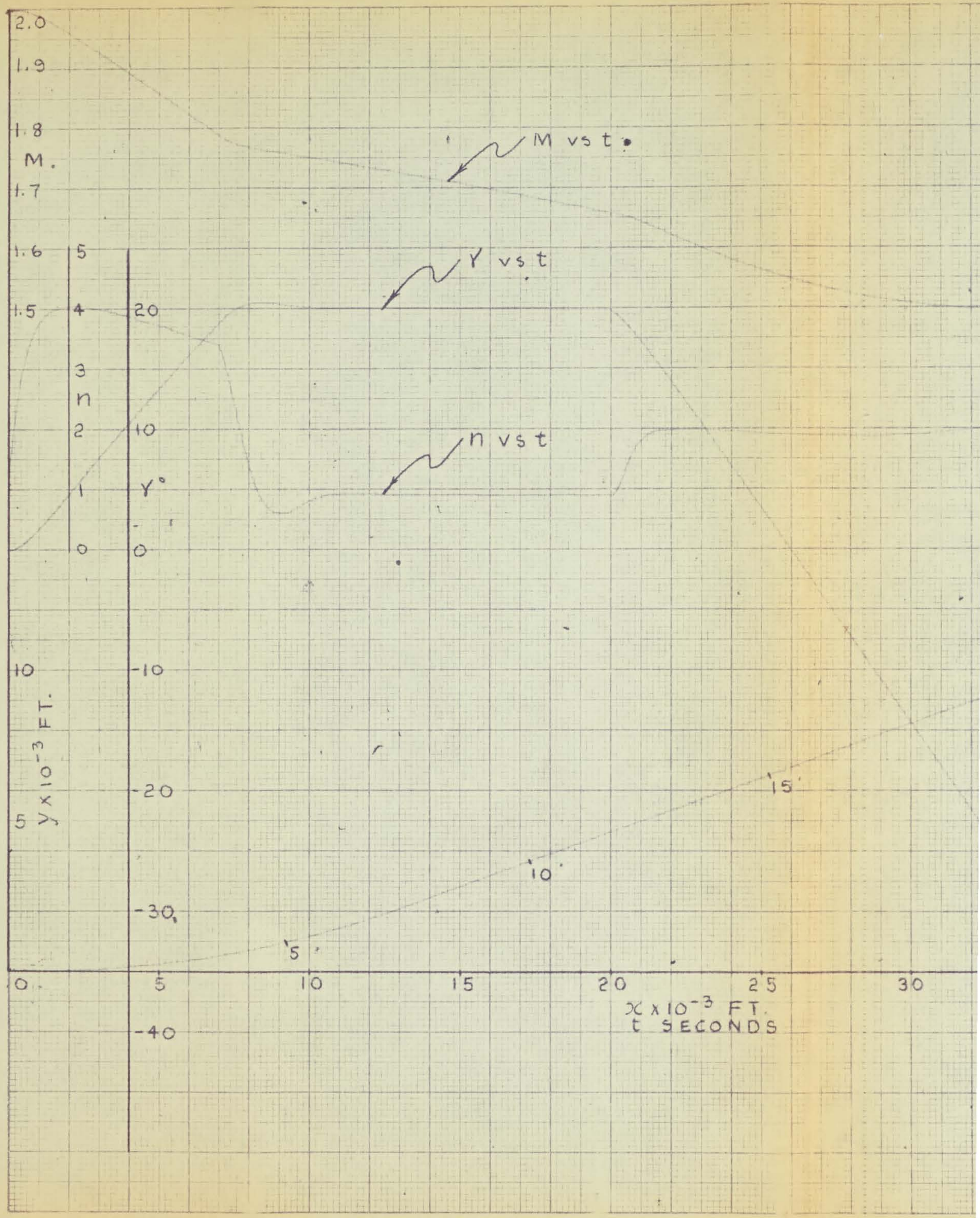


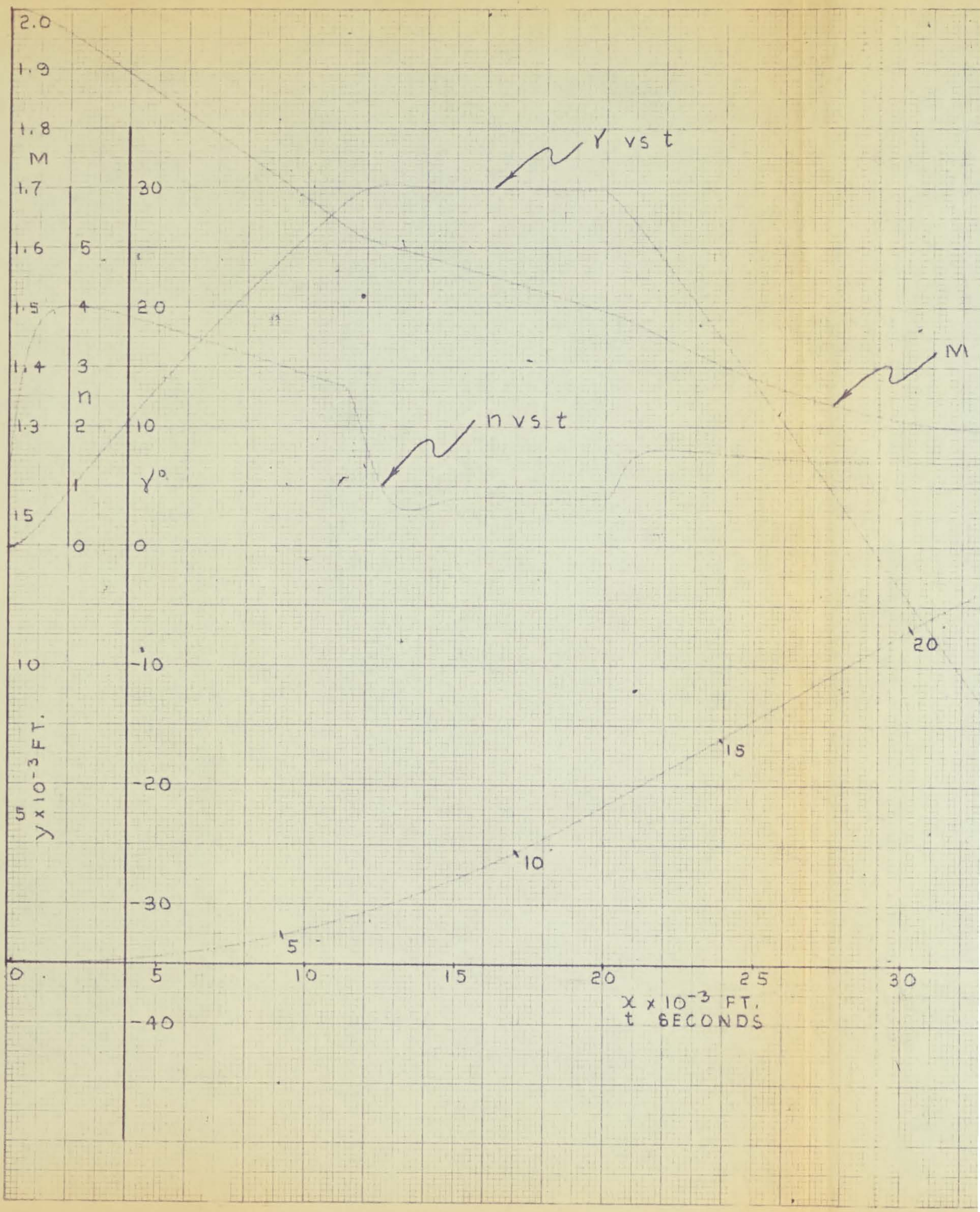
γ vs t
n vs. t
M vs. t
30
20
10
0
-10
-20
-30
γ°
1.5
1.4
1.3
M
1.2
1.1
1.0
4
3
2
n
1
0
10
5
y × 10⁻³ FT.
5
10
15
20
25
0
5
10
15
20
25
30
x × 10⁻³ FT.
t SECONDS

SECRET



2.0
1.9
1.8
M
1.7
1.6
5
4
3
n
2
1
0
20
10
0
γ°
-10
-20
-30
-40
10
5
y x 10^-3 FT.
M vs
n vs t
γ vs t
5
10
15
0
5
10
15
20
25
30
X x 10^-3 FT.
t SECONDS


M vs t
Y vs t
n vs t
M.
n
Y°
y x 10^-3 FT.
x x 10^-3 FT.
t SECONDS



2.0
1.9
1.8
M
1.7
1.6
1.5
1.4
1.3
15
10
5
y x 10^-3 FT.
5
4
3
n
2
1
0
30
20
10
γ°
0
-10
-20
-30
-40
γ vs t
n vs t
M
5
10
15
20
0
5
10
15
20
25
30
x x 10^-3 FT.
t SECONDS