AC 4
MIT. Office of the President
Box 104 Folder 5

GUIDED MISSILES
GUIDANCE AND CONTROL SYMPOSIUM
1947

Guided Missiles
Symposium

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Guided Missiles Program
Cambridge 39, Mass.

January 30, 1947

Presidents Office
RECEIVED
JAN 31 1947
Refer to
File

Mr. James R. Killian, Jr.
Room 3-208
M.I.T.

Dear Mr. Killian:

The M.I.T. guided missile groups engaged on the Meteor Program of the United States Navy are conducting a guidance and control symposium on February 6, 7, and 8, 1947. A tentative program for this symposium is enclosed.

You are cordially invited to attend any of the sessions which you believe would be of interest to you. Space limitations of room 10-250 make it important that the committee know which sessions each person wishes to attend, in order that as full a representation from other organizations may be accommodated. Will you kindly fill out and return the attached form by return mail or phone your choice to Miss Grinnell on extension 2338.

Very truly yours,

Albert C. Hall

Albert C. Hall
Chairman, Symposium Committee

PROGRAM

GUIDANCE AND CONTROL SYMPOSIUM

Huntington Hall, Rm. 10-250
Massachusetts Institute of Technology

REGISTRATION
Rm. 10-250
February 6, 1947, 0800-0900

SESSION 1.
February 6, 1947, 0900-1230

INTELLIGENCE SYSTEMS
Chairman - Dr. J. A. Stratton

Papers:

1. The Effect of Military Tactics on Guidance and Control Requirements.
   Captain Stedman Teller, U. S. Navy

2. Fundamental Aspects of Radar for Detection and Guidance.
   Dr. Edwin Snyder, Stevens Institute of Technology

Schneider?

3. Fundamental Limitations of Radio Navigation Systems.
   Dr. J. A. Pierce, Harvard University

SESSION 2.
February 6, 1947, 1330-1700

INTELLIGENCE SYSTEMS
Chairman - Professor J. B. Wiesner

Papers:

1. A Critical Comparison of the Fundamental Limitations of Navigation by Celestial Means and Navigation by Dead Reckoning Means.
   Dr. C. S. Draper, Massachusetts Institute of Technology

2. Fundamental Limitations of Infra-Red Detection Systems.
   Dr. John Strong, Johns Hopkins University

3. Practical Problems Encountered in the Development of a Radar Guidance System for a Homing Missile.
   Dr. P. R. Stout, University of California

SESSION 3.
February 7, 1947, 0900-1230

DYNAMICS AND CONTROL
Chairman - Dr. A. C. Hall

Papers:

1. Application of Automatic Control Theory to Missile Dynamics.
   Mr. Herbert Harris, Sperry Gyroscope Company

2. Aerodynamic Aspects of Stability and Control.
   Dr. H. J. Stewart, California Institute of Technology

3. Practical Dynamic Problems Encountered in Missile Control.
   Dr. D. T. Sigley, Applied Physics Laboratory, Johns Hopkins University

SESSION 4.
February 7, 1947, 1330-1700

MISSILE COMPONENTS AND TRAJECTORY ANALYSIS
Chairman - Dr. H. G. Stever

Papers:

1. Survey of Servo and Gyro Elements Suitable for Missile Control
   Presented by representatives of several organizations active in this field

2. Fundamental Trajectory Dynamics.
   Dr. F. E. Bothwell, Massachusetts Institute of Technology

3. Trajectory Analysis Considerations in a Practical Missile.
   Dr. H. W. Bode, Bell Telephone Laboratories

SESSION 5.
February 8, 1947, 0900-1230

SIMULATORS
Chairman - Dr. G. S. Brown

Papers:

1. Application of Computing Machines to Guided Missile Problems.
   Mr. Perry Crawford, Office of Naval Research, U. S. Navy

2. Development of a Partial Simulator for a Homing Type Missile.
   Dr. H. K. Skramstad, National Bureau of Standards

3. Survey of Simulator Status in United States.
   Presented by representatives of several organizations active in this field

GUIDED MISSILES PROGRAM

Room 20-B-245

3 February 1947

To: Members of the Executive Committee

Professor Stratton	Mr. B. Whitman
" Markham	Professor Wiesner
" Hottel	Professor Hall
" Williams	

From: H. Guyford Stever

Subj: Budget Revision

Encls:

Chart "A"	Modified Plan for Associated Contractors	
Chart "B"	Modified Plan for MIT	
Graph I	Modified Total Budget	- Breakdown by Contractor
" II	" " "	- Breakdown by Phase
" III	Modified Associated Contractors Budget	
" IV	Modified MIT Budget	

The attached charts and graphs are similar to those presented at the Executive Committee Meeting of January 27, 1947, under the general heading of Plan "C", except that they incorporate certain modifications suggested by the Committee.

Essentially, this present plan calls for the design, fabrication and test of only two types of test vehicles - one rocket-propelled and one ram-jet propelled. Each test vehicle is to be considered as a combined vehicle, suitable for testing all phases of missile design, i.e., Propulsion, Aero-dynamics, Control, and Guidance.

In addition, all design studies and fabrication of one type of vehicle will be done by one Associated Contractor, resulting in a cleaner assignment of tasks and less overlapping of effort. There is considerable saving in design, development and fabrication costs by making combined test vehicles, as well as savings in time.

The figures showing the allocation of funds to MIT and Associated Contractors, as well as to the various phases of the program, represent an attempt to evaluate the requirements of the different lines of endeavor involved. They should not, however, be considered as "frozen", as it is intended that this program shall be flexible enough to allow for change as the necessity developes. It is impossible to lay out a completely hard and fast program for research and development work. However, so that efforts will be directed constantly toward the ultimate goal, it is necessary to formulate a general plan in which the details can be varied as the work progresses.

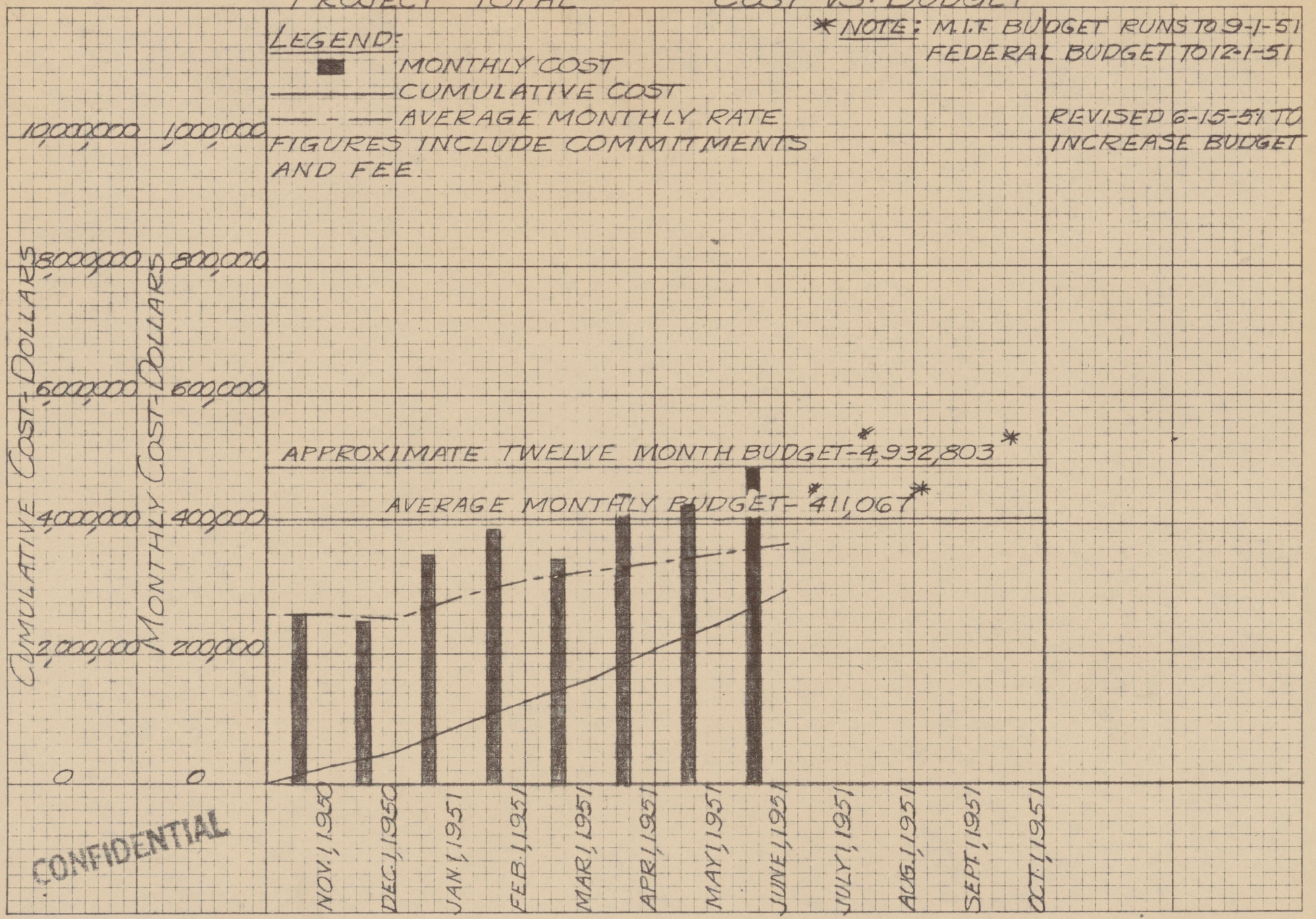
RHS/mrh

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

(Norwood) #3

PROJECT METEOR

PROJECT TOTAL —— COST VS. BUDGET



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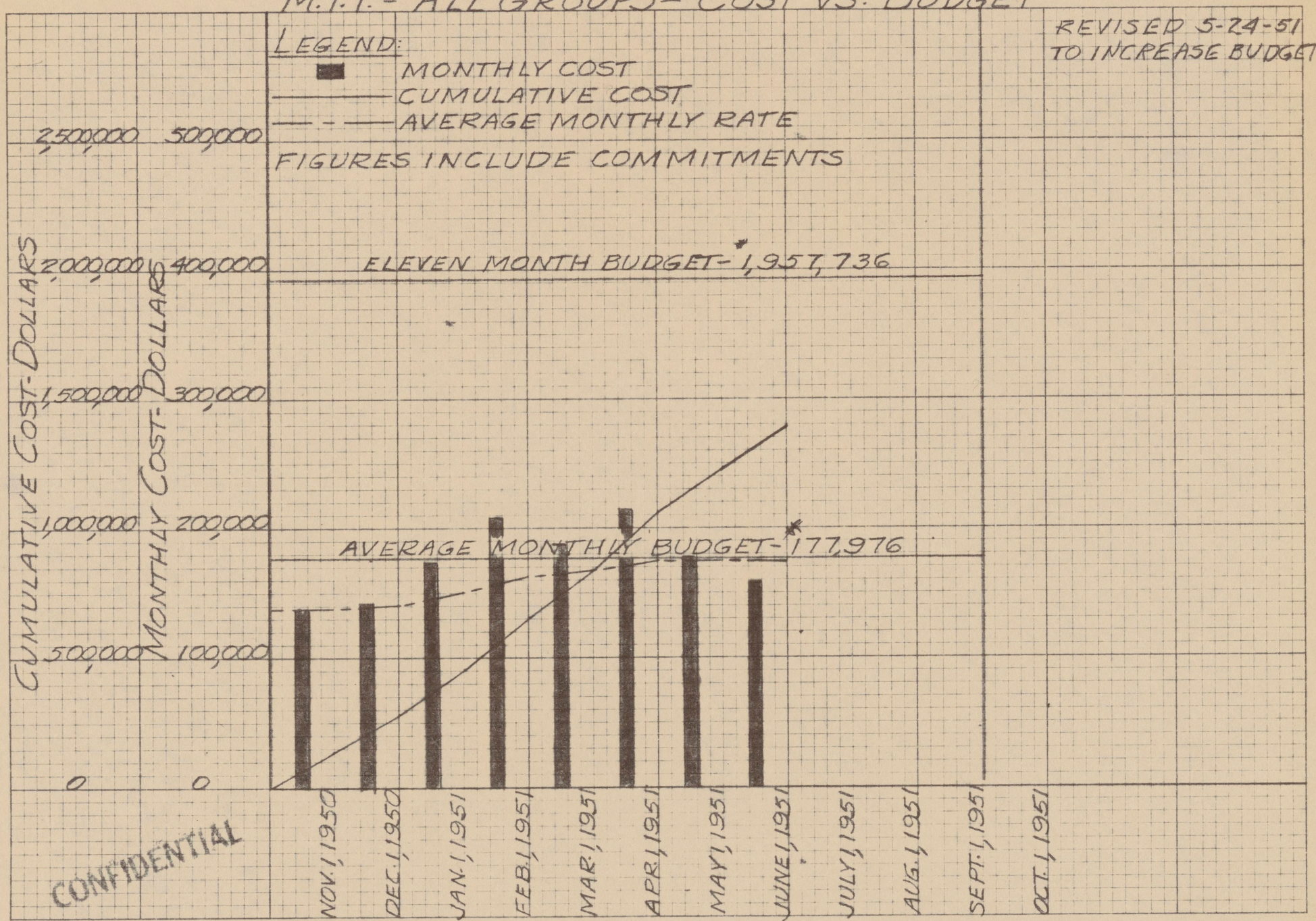
2

PROJECT METEOR

M.I.T. - ALL GROUPS - COST VS. BUDGET

REVISED 5-24-51
TO INCREASE BUDGET



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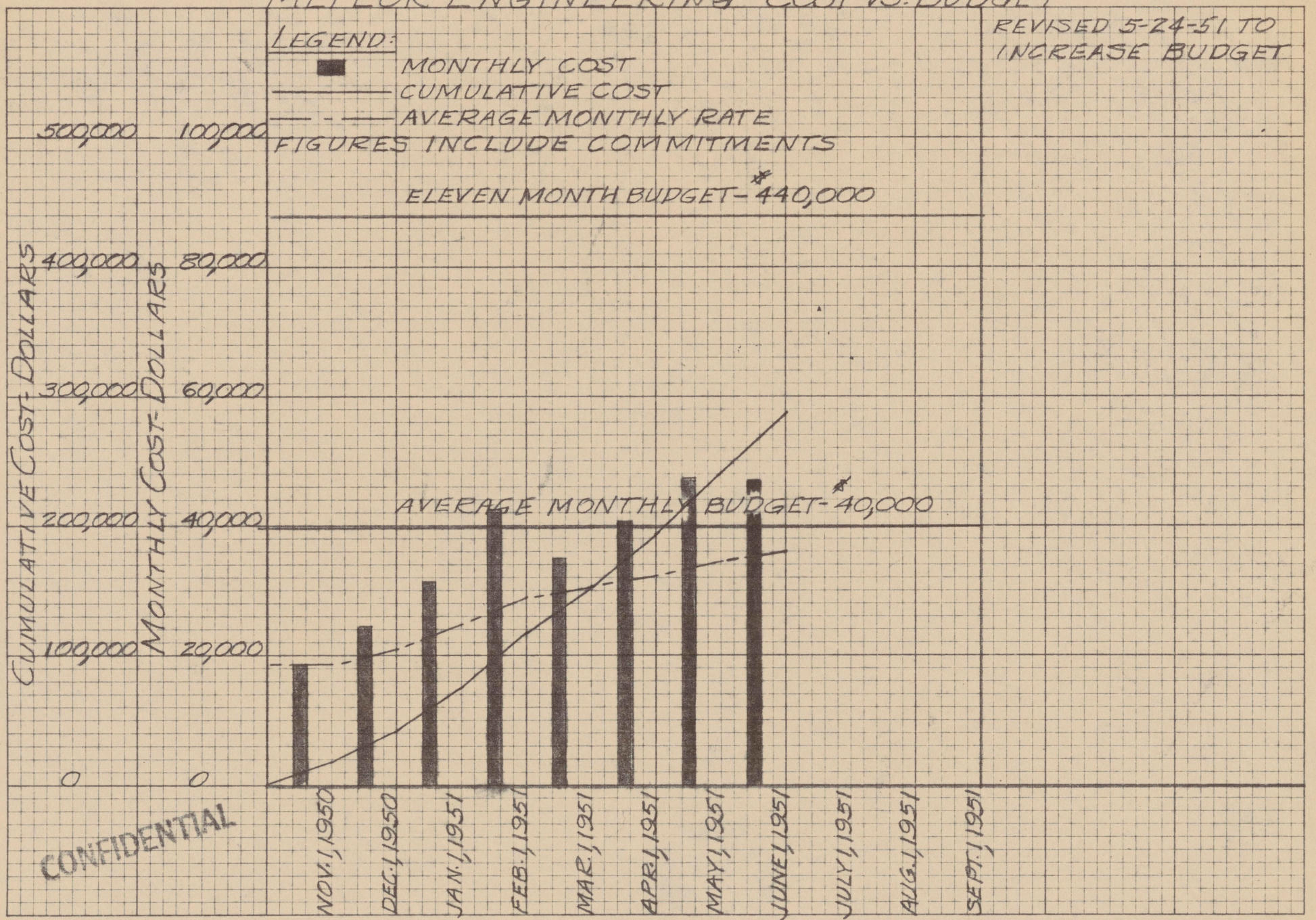
3

PROJECT METEOR

METEOR ENGINEERING - COST VS. BUDGET



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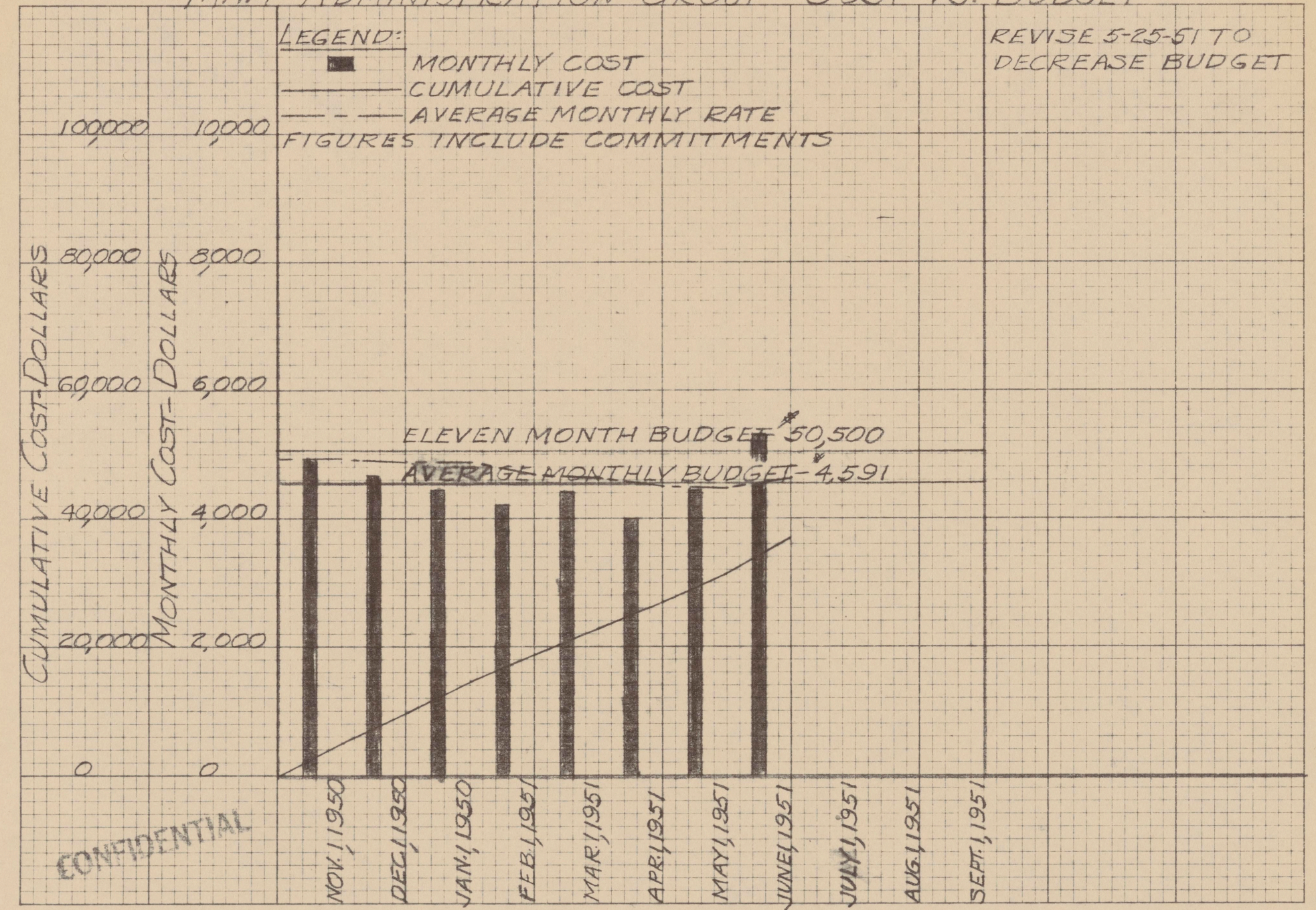
PROJECT METEOR

M.I.T. ADMINISTRATION GROUP - COST VS. BUDGET



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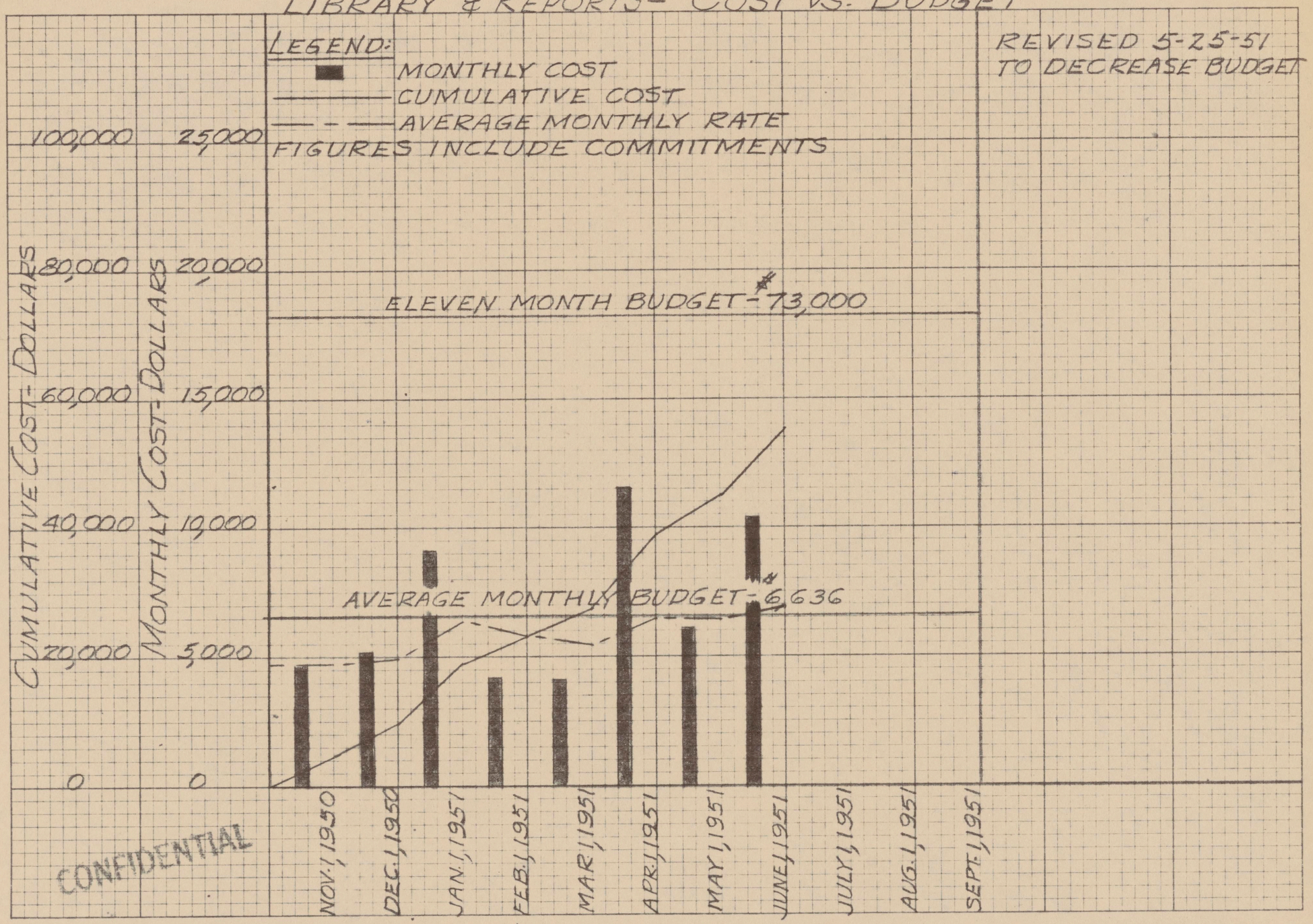
5

PROJECT METEOR

LIBRARY & REPORTS - COST VS. BUDGET



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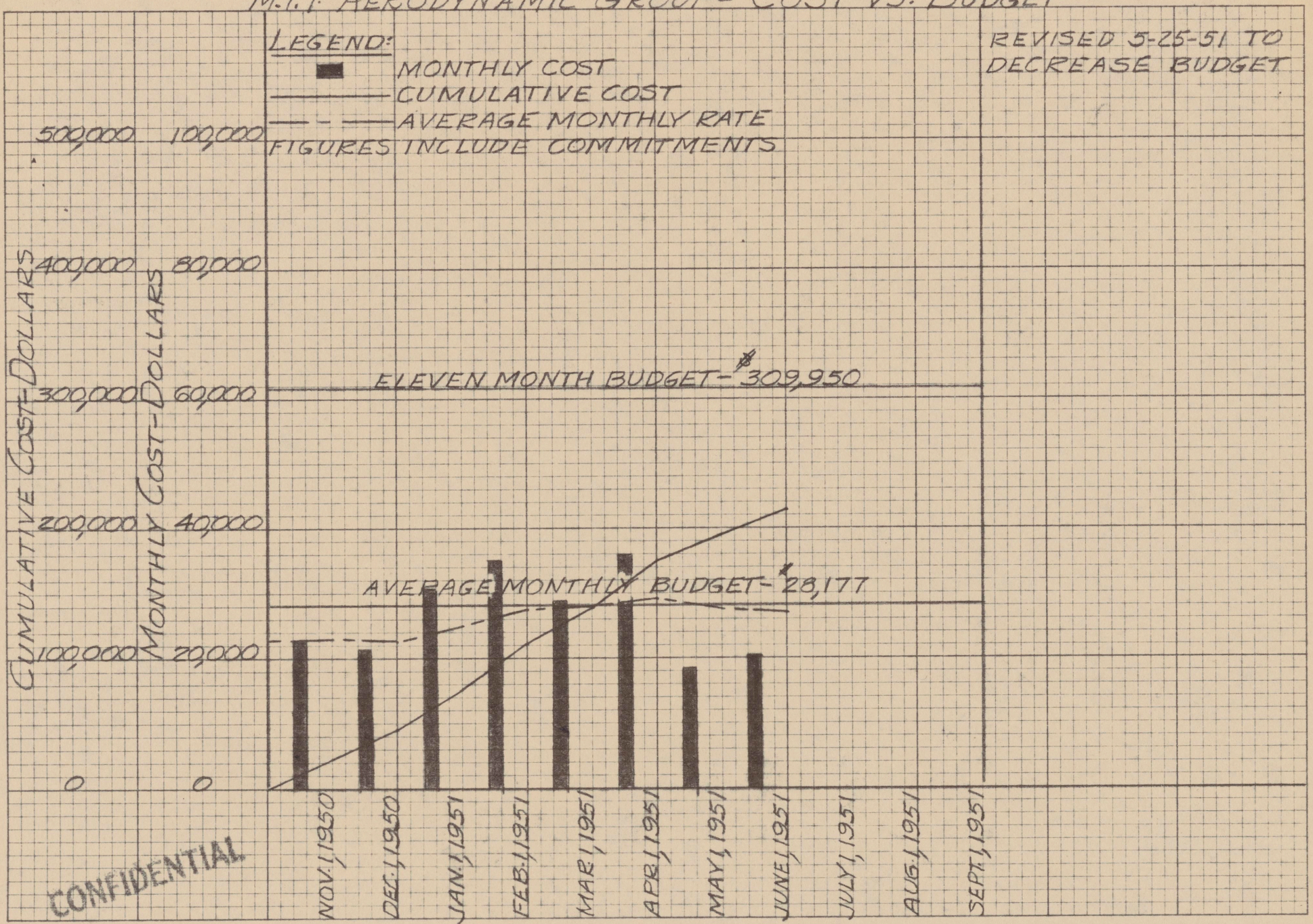
PROJECT METEOR

M.I.T. AERODYNAMIC GROUP - COST VS. BUDGET



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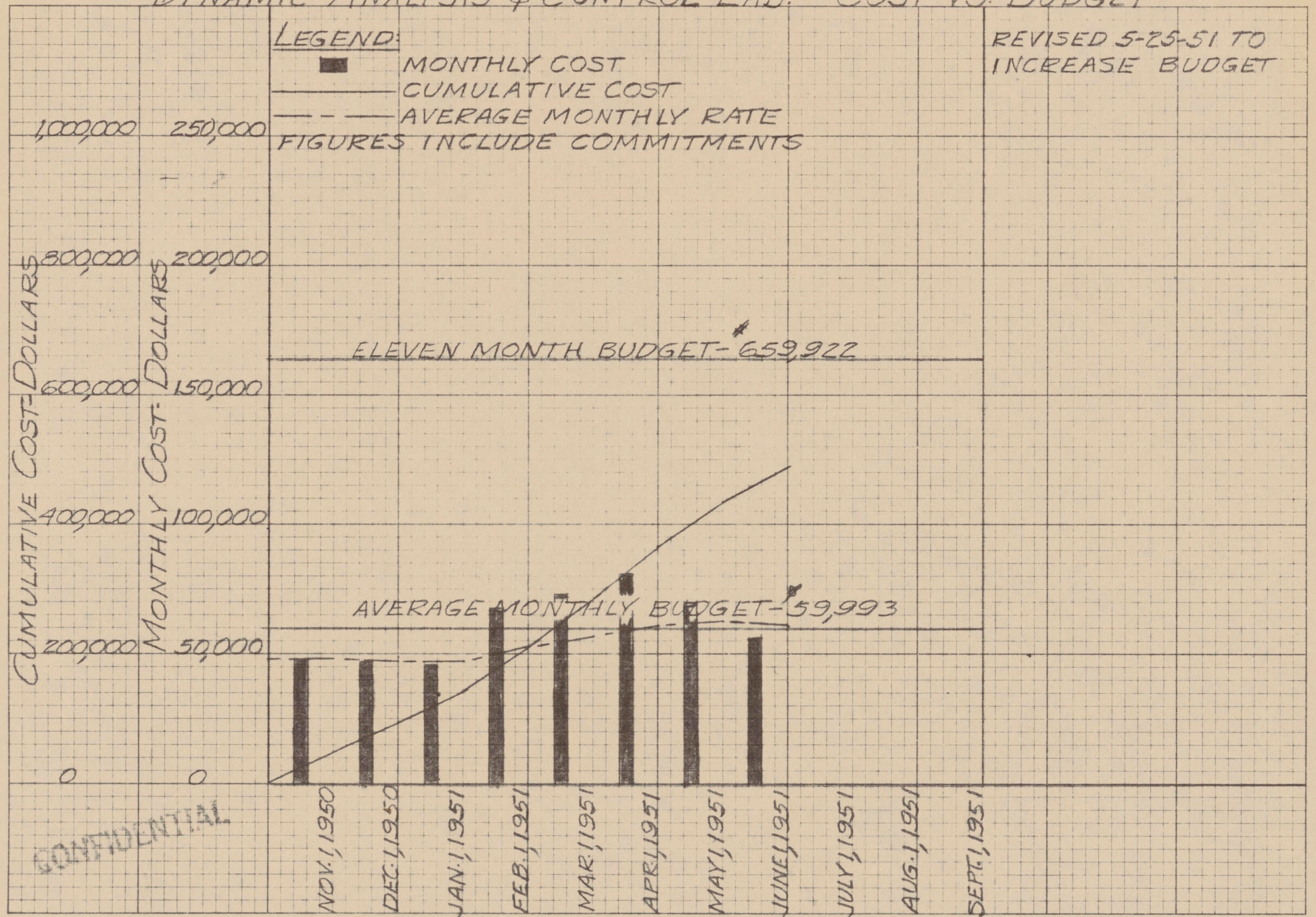
PROJECT METEOR

DYNAMIC ANALYSIS & CONTROL LAB. – COST VS. BUDGET



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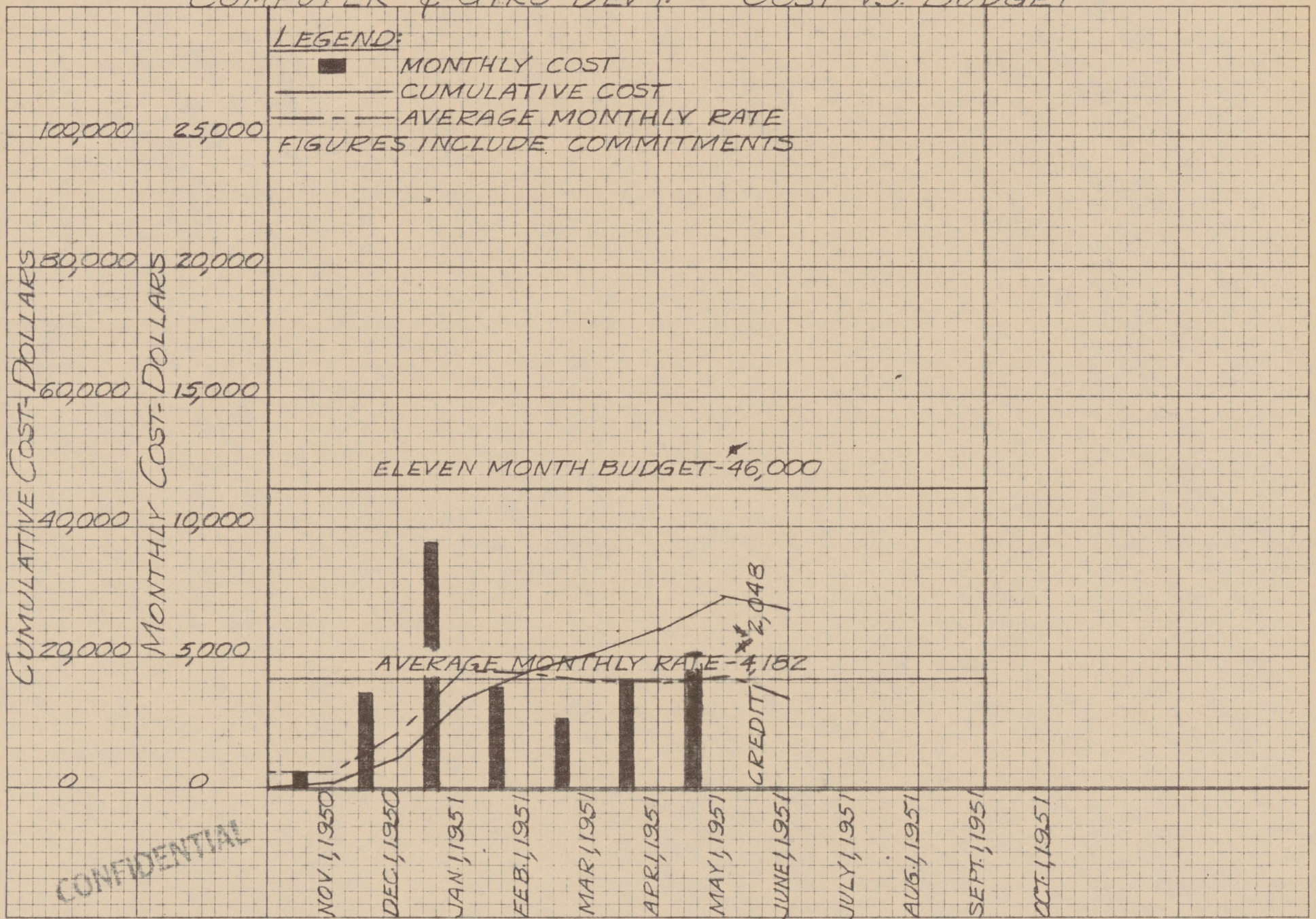
8

PROJECT METEOR

COMPUTER & GYRO DEV'T. — COST VS. BUDGET



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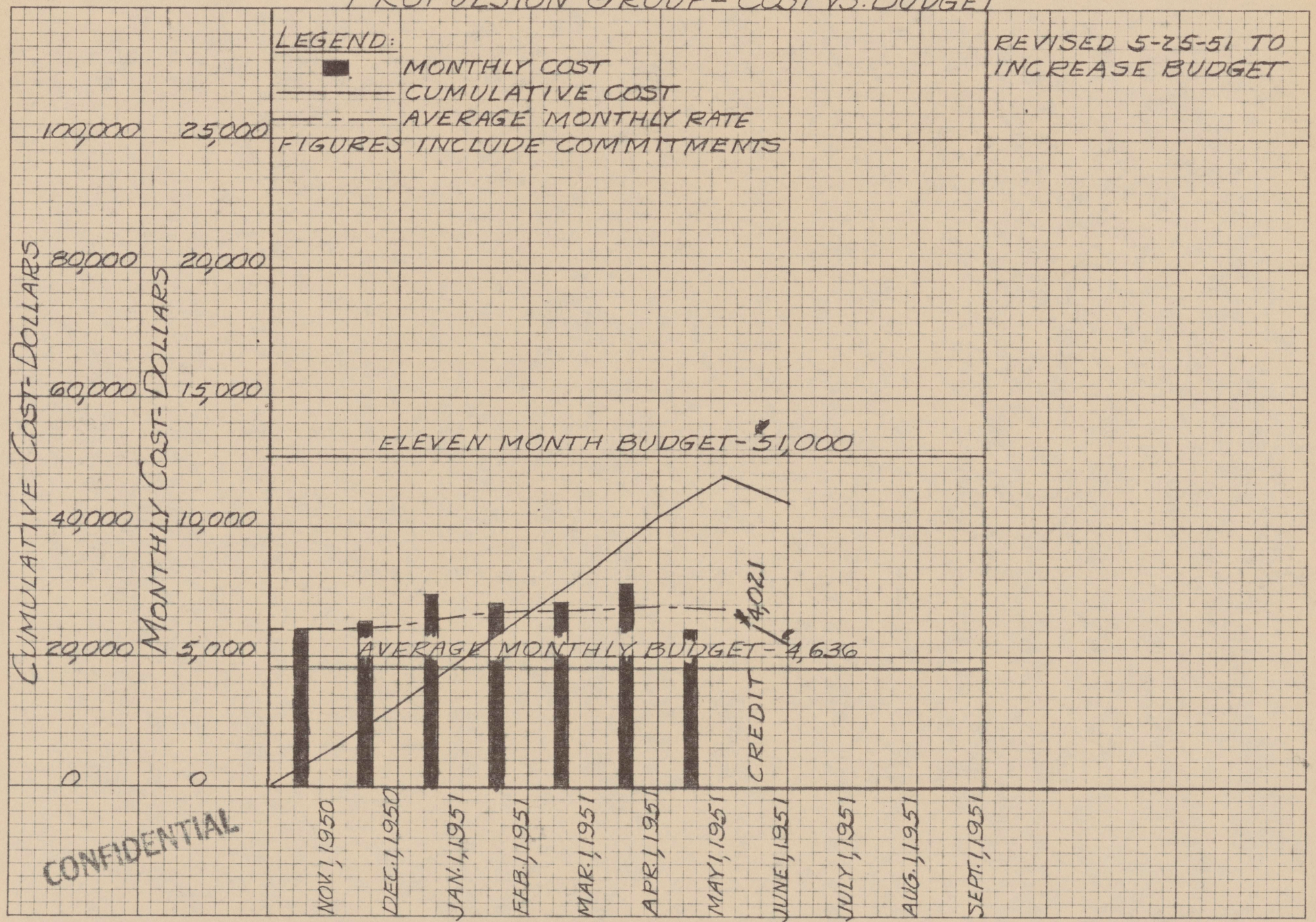
9

PROJECT METEOR

PROPULSION GROUP - COST VS. BUDGET



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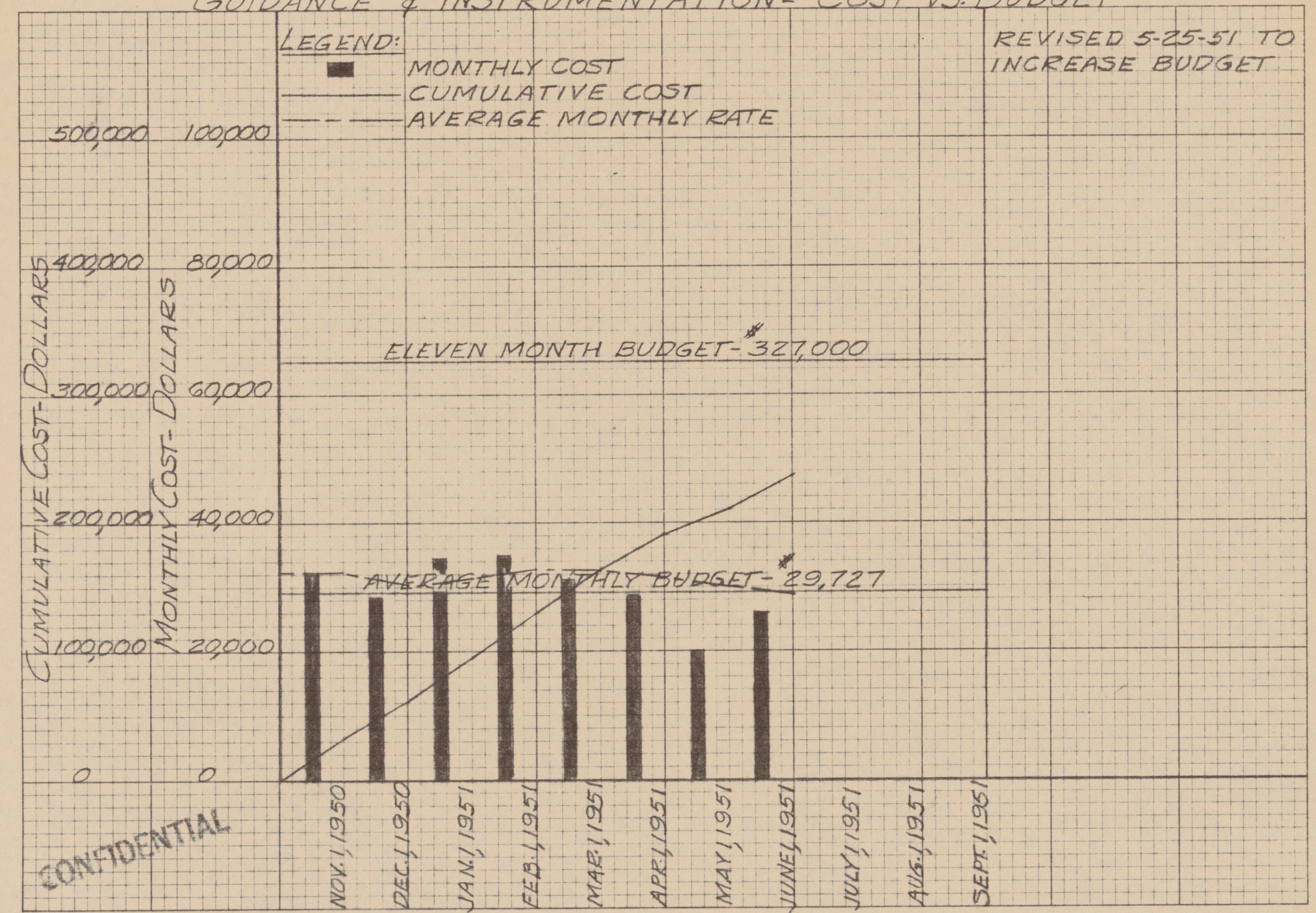
10

PROJECT METEOR

GUIDANCE & INSTRUMENTATION - COST VS. BUDGET



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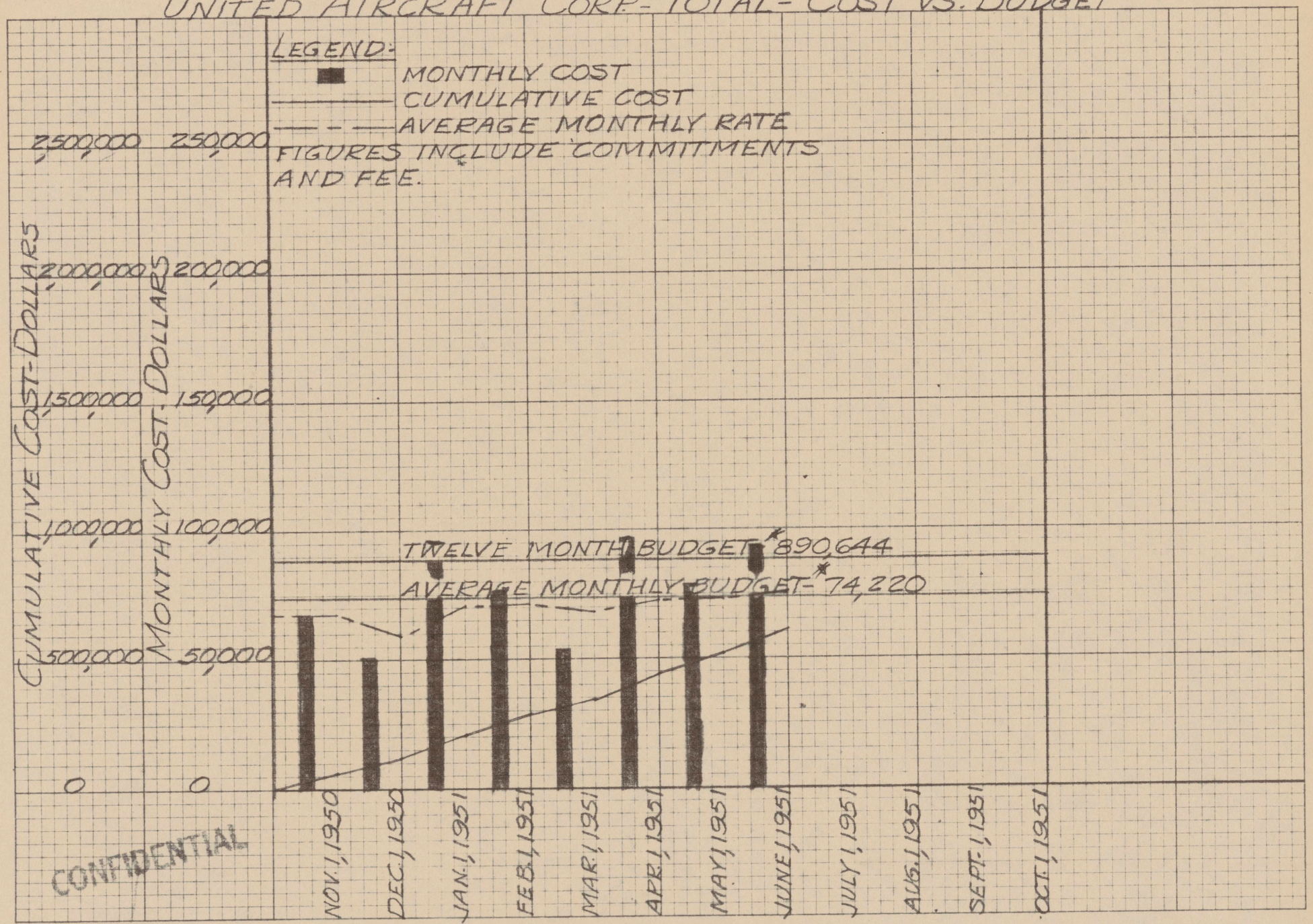
11

PROJECT METEOR

UNITED AIRCRAFT CORP. - TOTAL - COST VS. BUDGET



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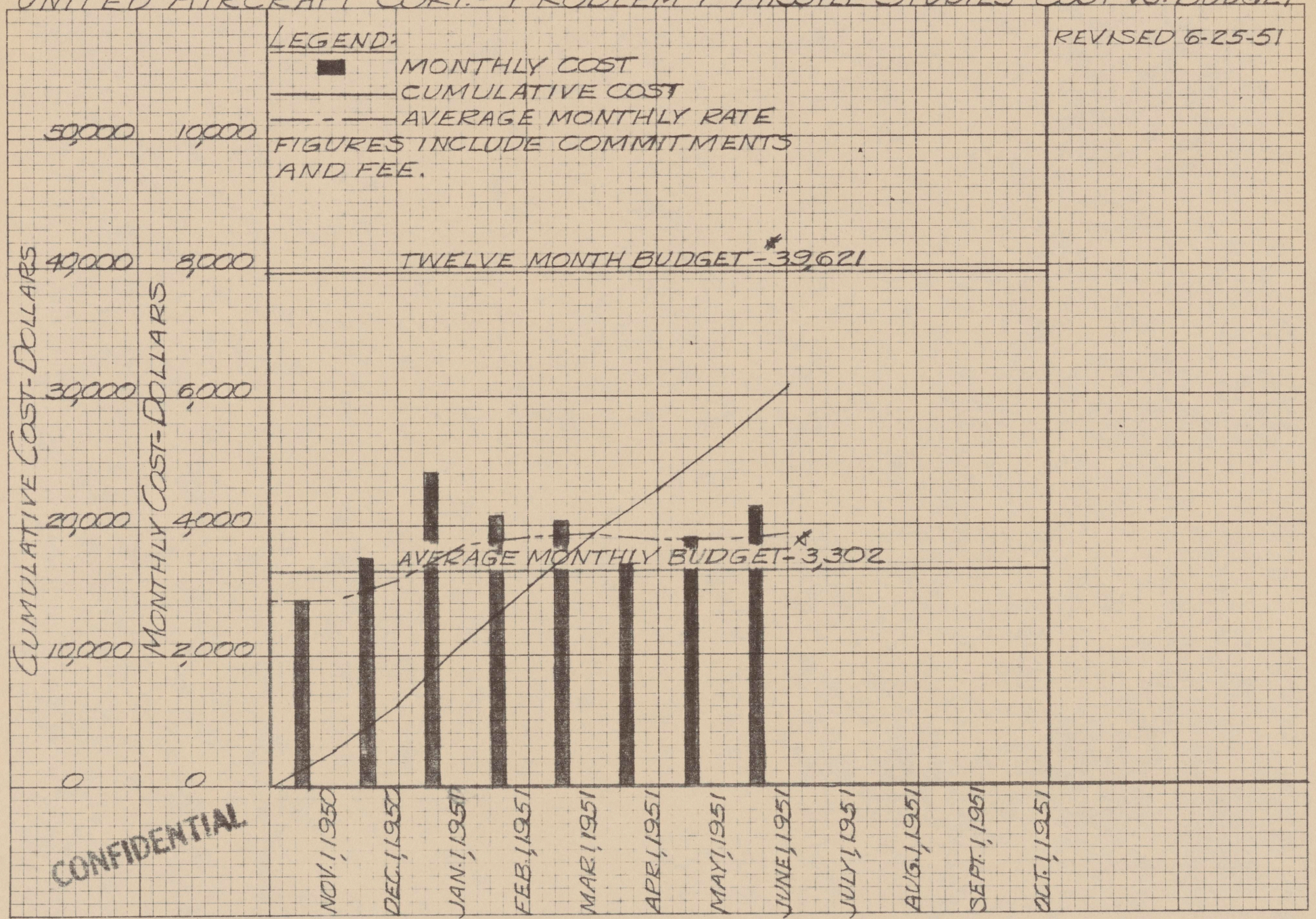
12

PROJECT METEOR

UNITED AIRCRAFT CORP.- PROBLEM 7-MISSILE STUDIES- COST VS. BUDGET

REVISED 6-25-51



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13

PROJECT METEOR

UNITED AIRCRAFT CORP. - PROBLEM 8 - BURNER DEV'T. - COST VS. BUDGET

REVISED 6-26-51

LEGEND:
- MONTHLY COST
- CUMULATIVE COST
- AVERAGE MONTHLY RATE

FIGURES INCLUDE COMMITMENTS AND FEE.

CUMULATIVE COST DOLLARS: 1,000,000; 800,000; 600,000; 400,000; 200,000; 0

MONTHLY COST DOLLARS: 100,000; 80,000; 60,000; 40,000; 20,000; 0

TWELVE MONTH BUDGET - 510,636

AVERAGE MONTHLY BUDGET - 42,553

NOV. 1, 1950 | DEC. 1, 1950 | JAN. 1, 1951 | FEB. 1, 1951 | MAR. 1, 1951 | APR. 1, 1951 | MAY 1, 1951 | JUNE 1, 1951 | JULY 1, 1951 | AUG. 1, 1951 | SEPT. 1, 1951 | OCT. 1, 1951

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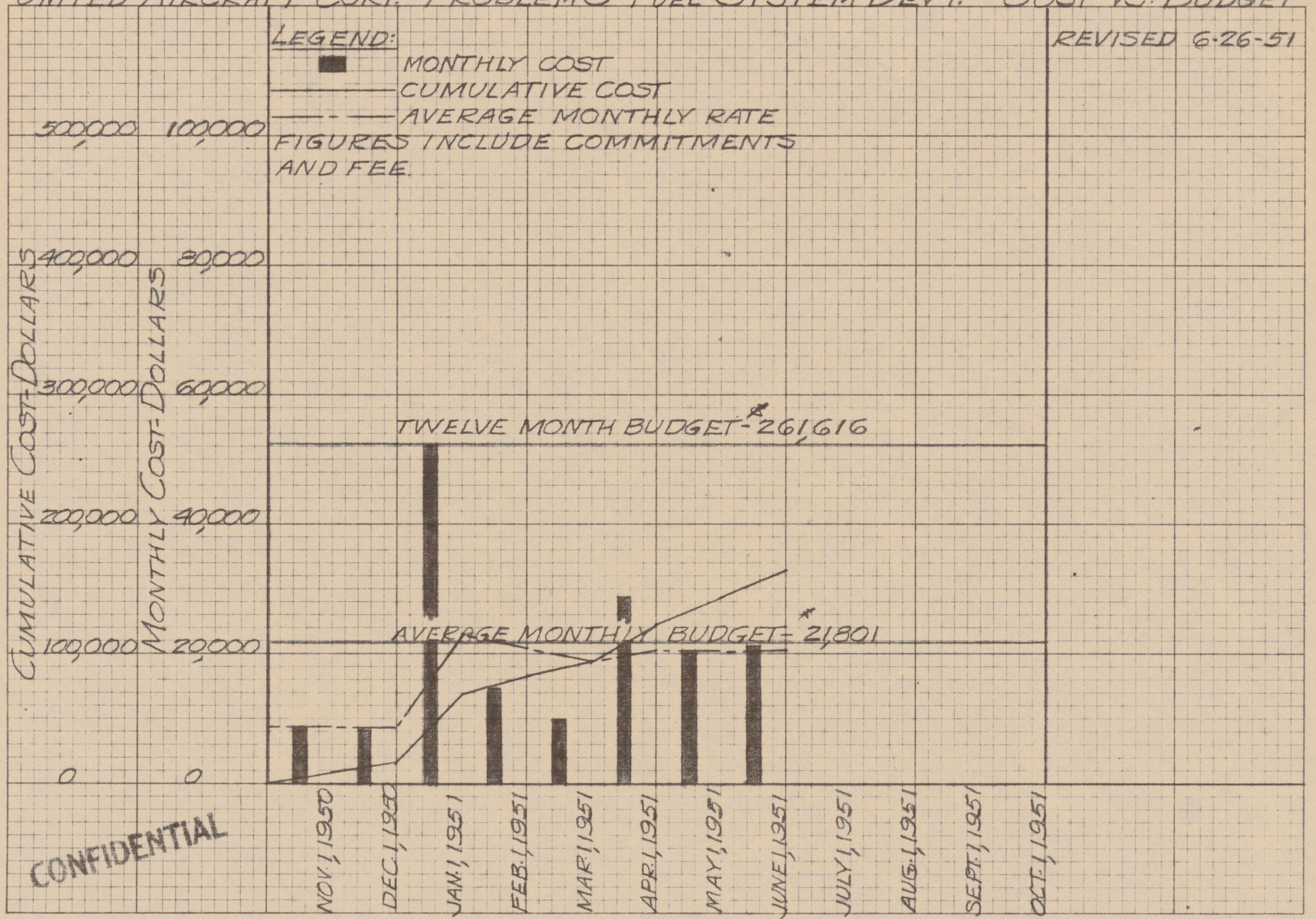
PROJECT METEOR

UNITED AIRCRAFT CORP. - PROBLEM 9 - FUEL SYSTEM DEV'T. - COST VS. BUDGET



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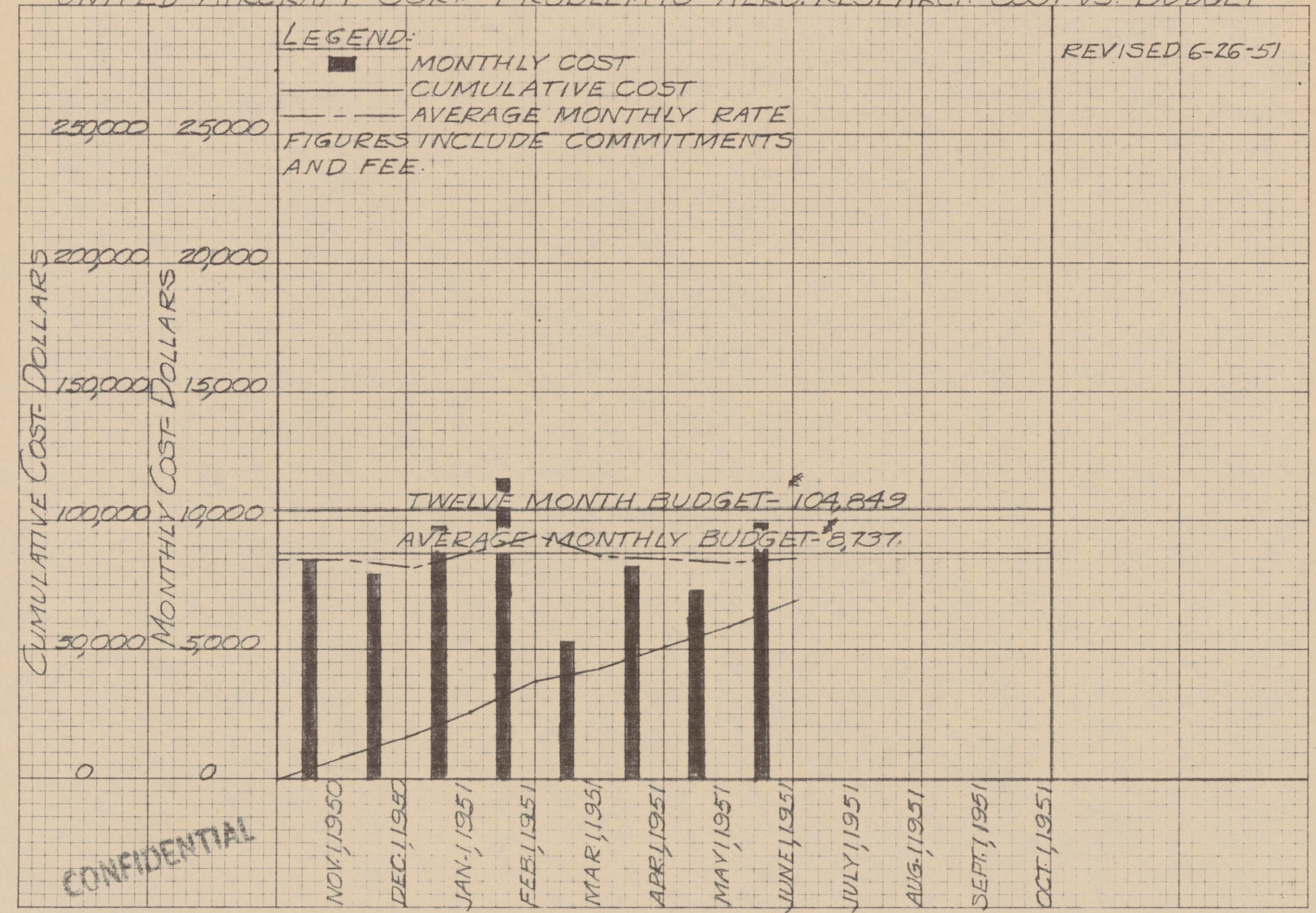
PROJECT METEOR

UNITED AIRCRAFT CORP.- PROBLEM 10- AERO. RESEARCH- COST VS. BUDGET



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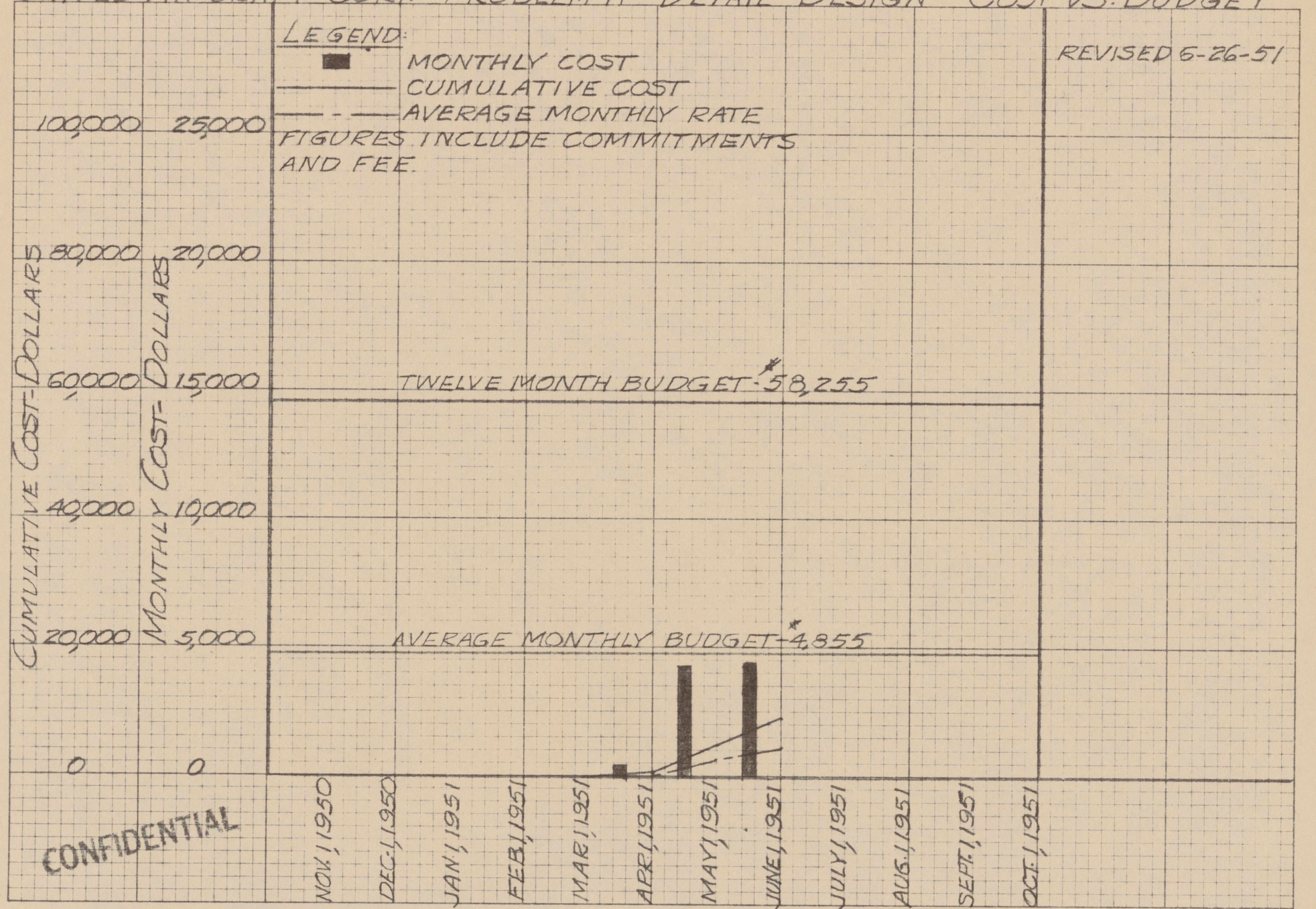
PROJECT METEOR

UNITED AIRCRAFT CORP.- PROBLEM II- DETAIL DESIGN- COST VS. BUDGET



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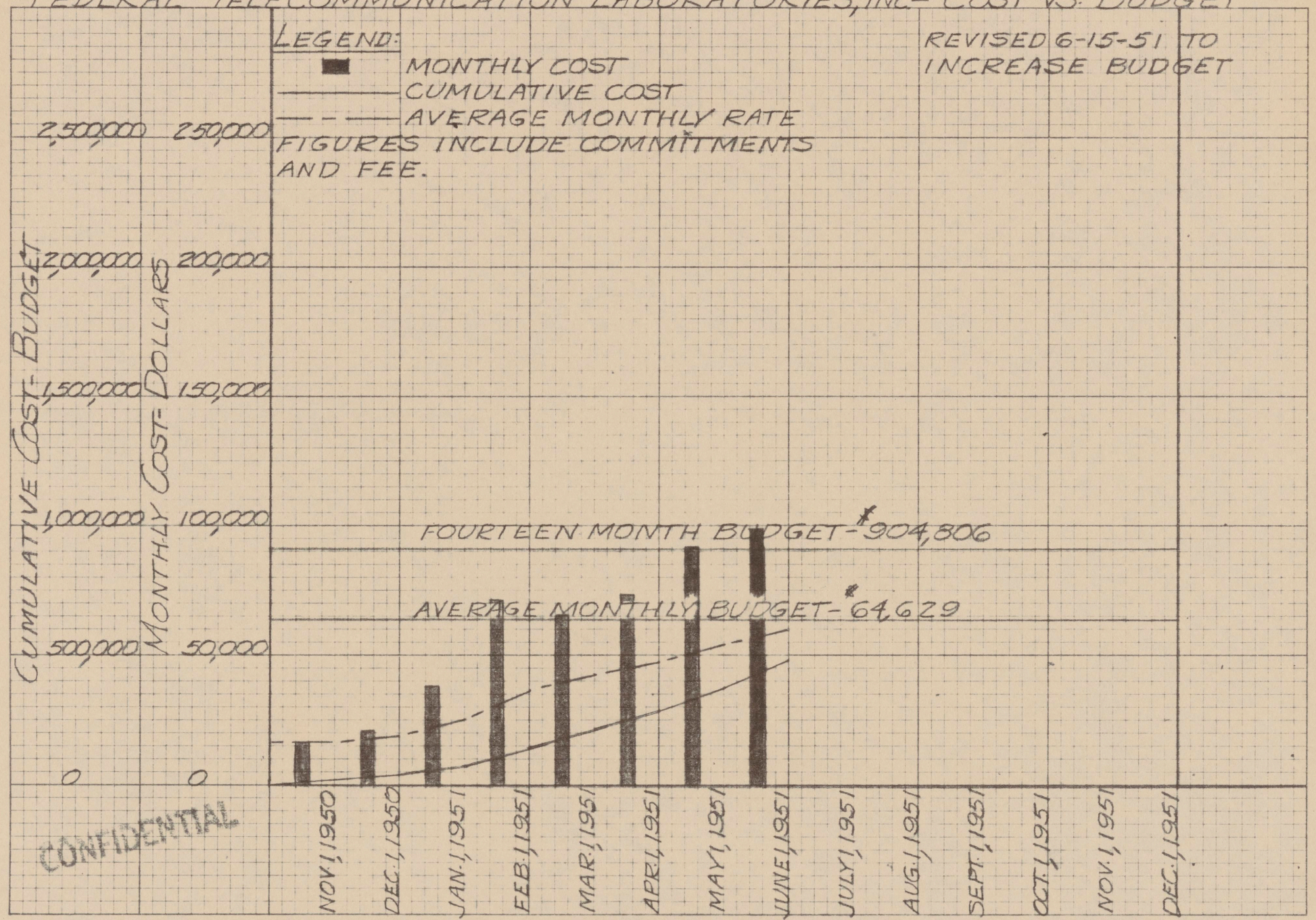
PROJECT METEOR

FEDERAL TELECOMMUNICATION LABORATORIES, INC.- COST VS. BUDGET



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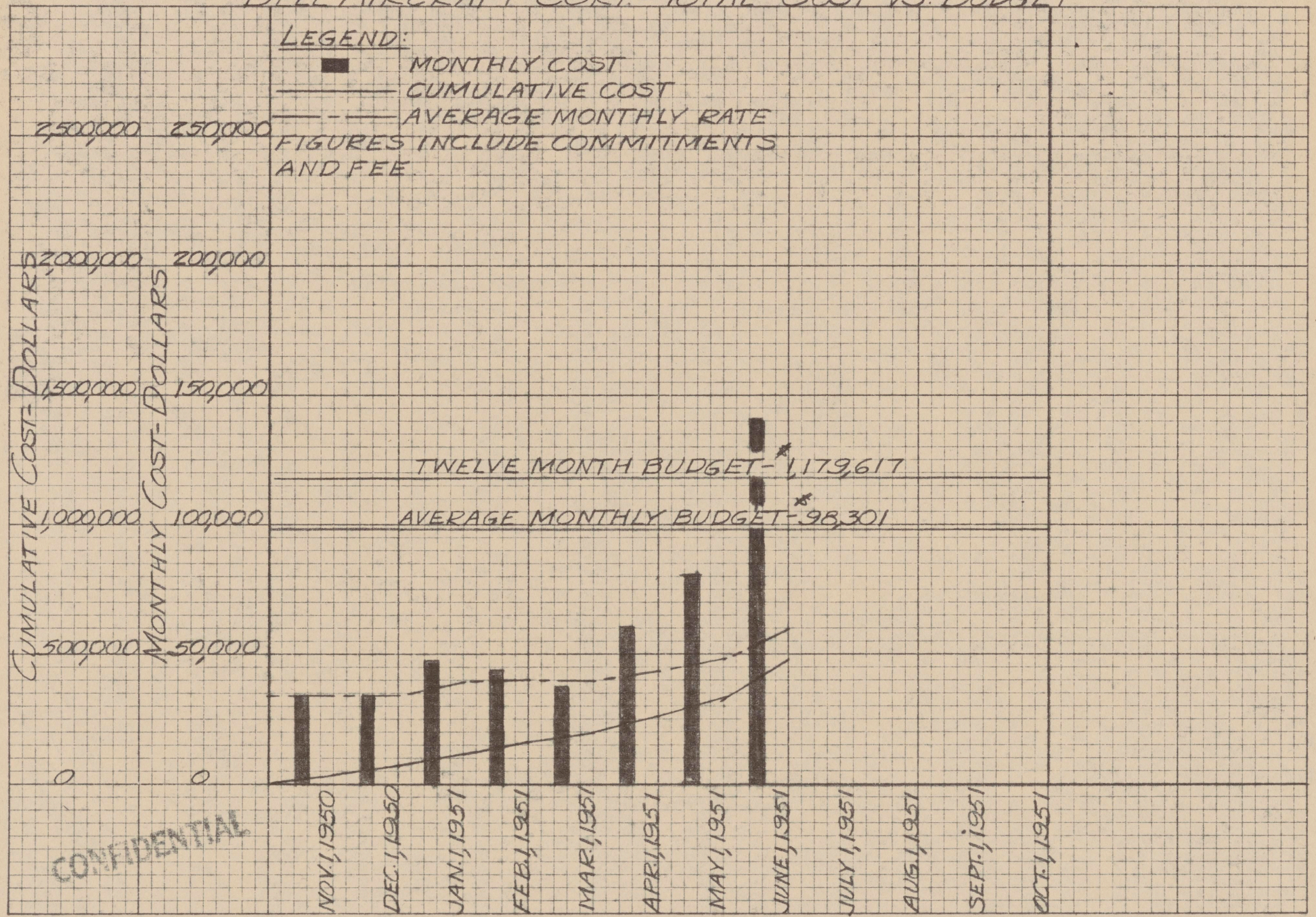
PROJECT METEOR

BELL AIRCRAFT CORP.- TOTAL- COST VS. BUDGET



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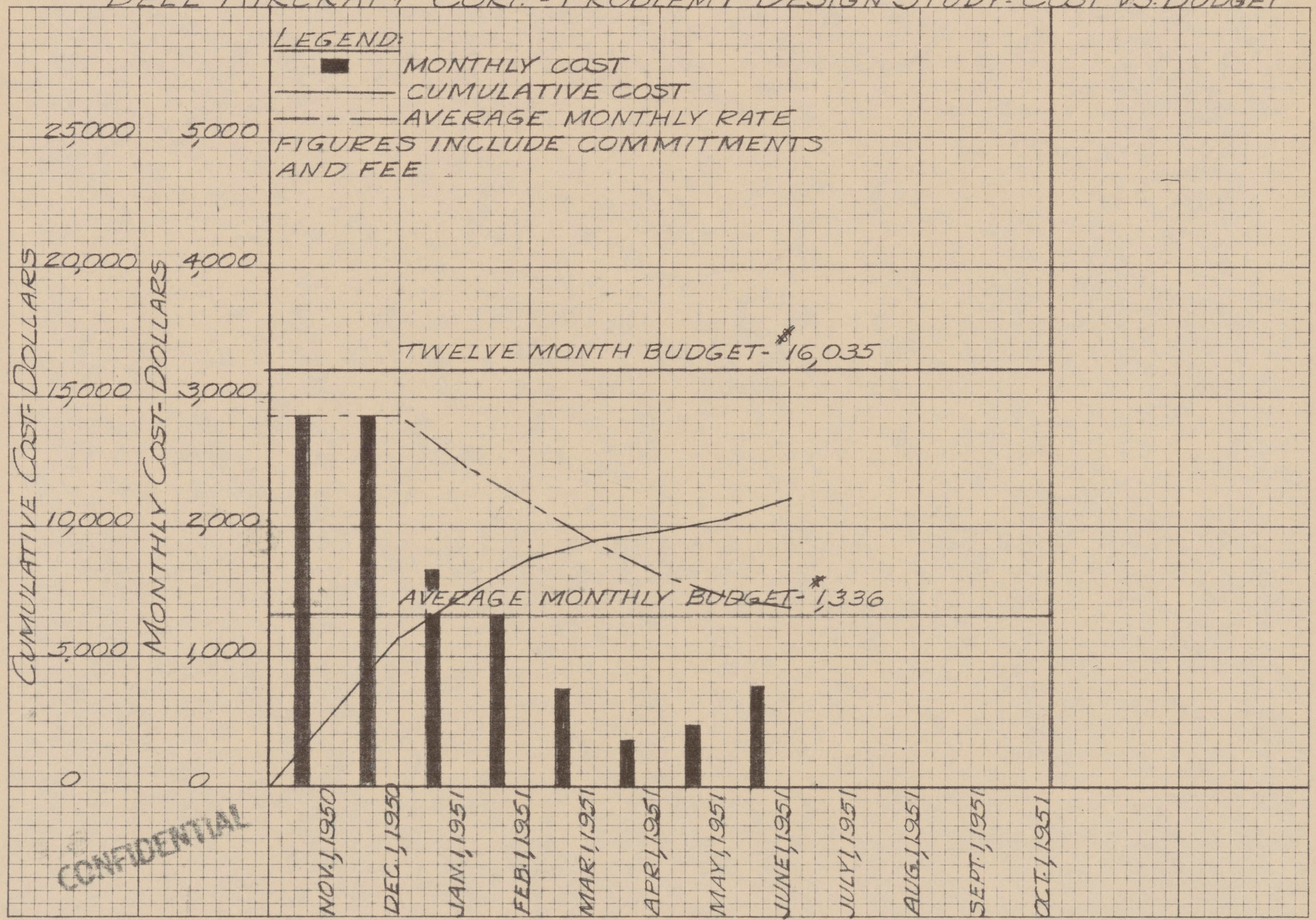
PROJECT METEOR

BELL AIRCRAFT CORP. - PROBLEM 1 - DESIGN STUDY - COST VS. BUDGET



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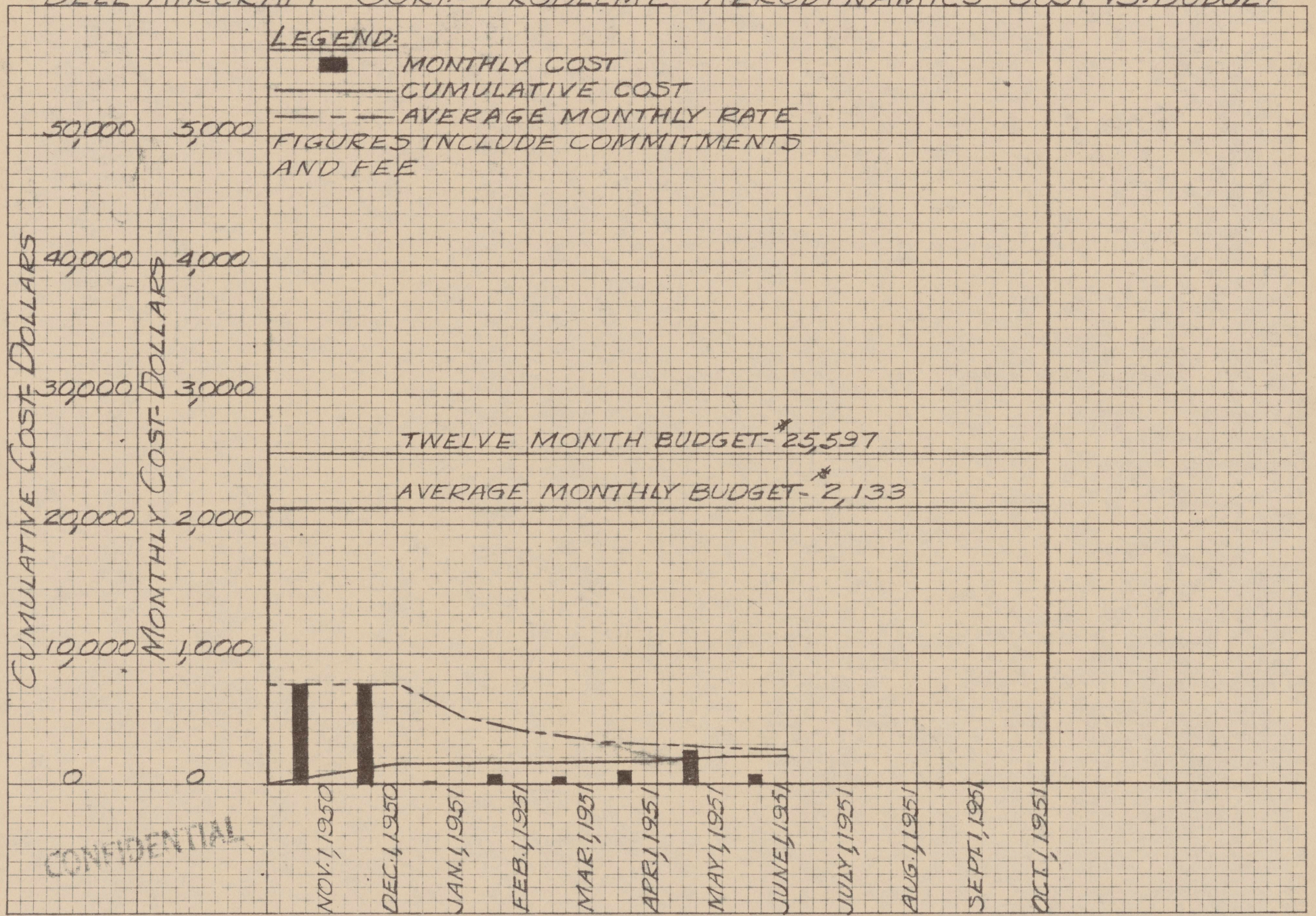
PROJECT METEOR

BELL AIRCRAFT CORP.- PROBLEM 2 - AERODYNAMICS - COST VS. BUDGET



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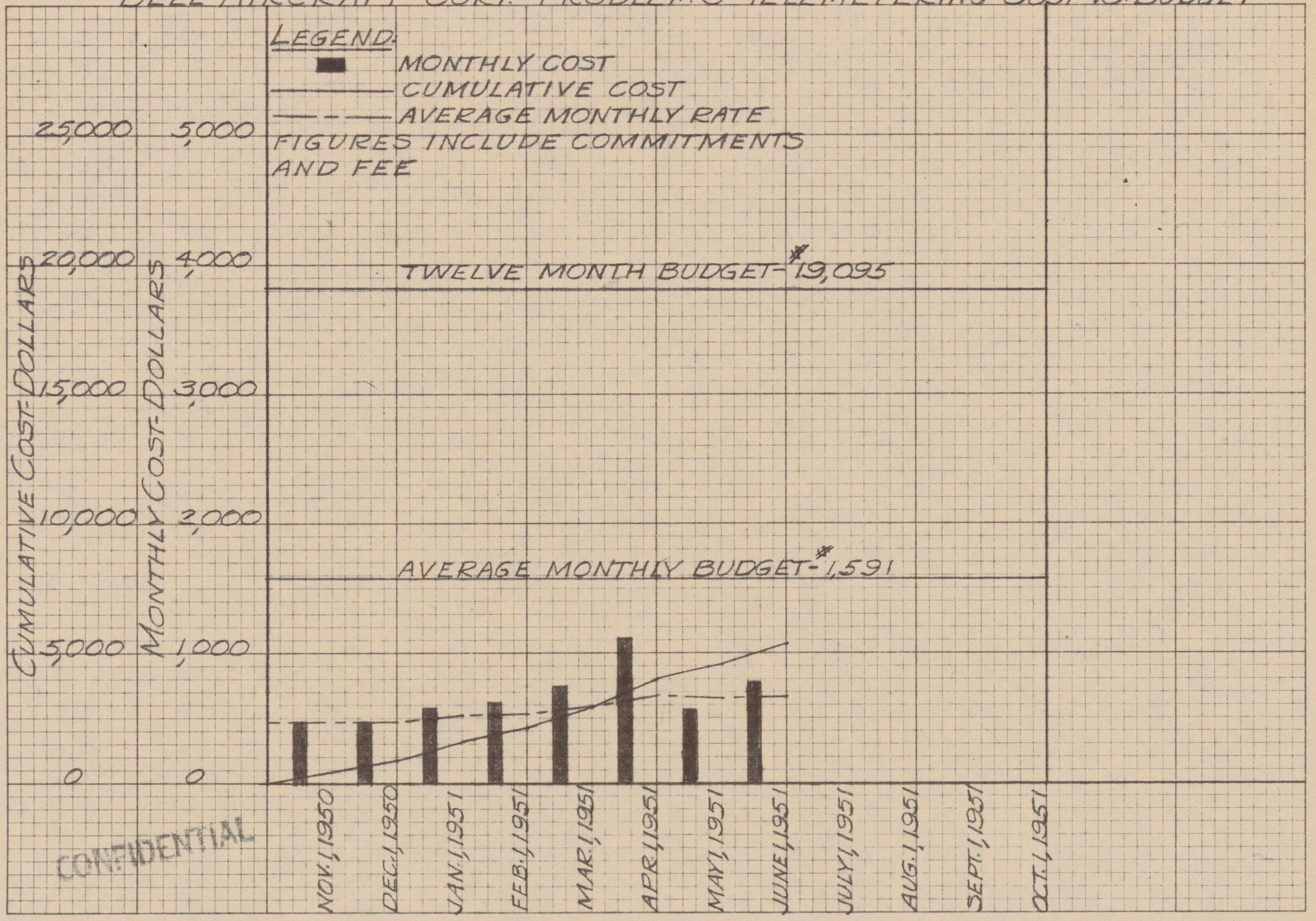
PROJECT METEOR

BELL AIRCRAFT CORP.- PROBLEM 3 - TELEMETERING - COST VS. BUDGET



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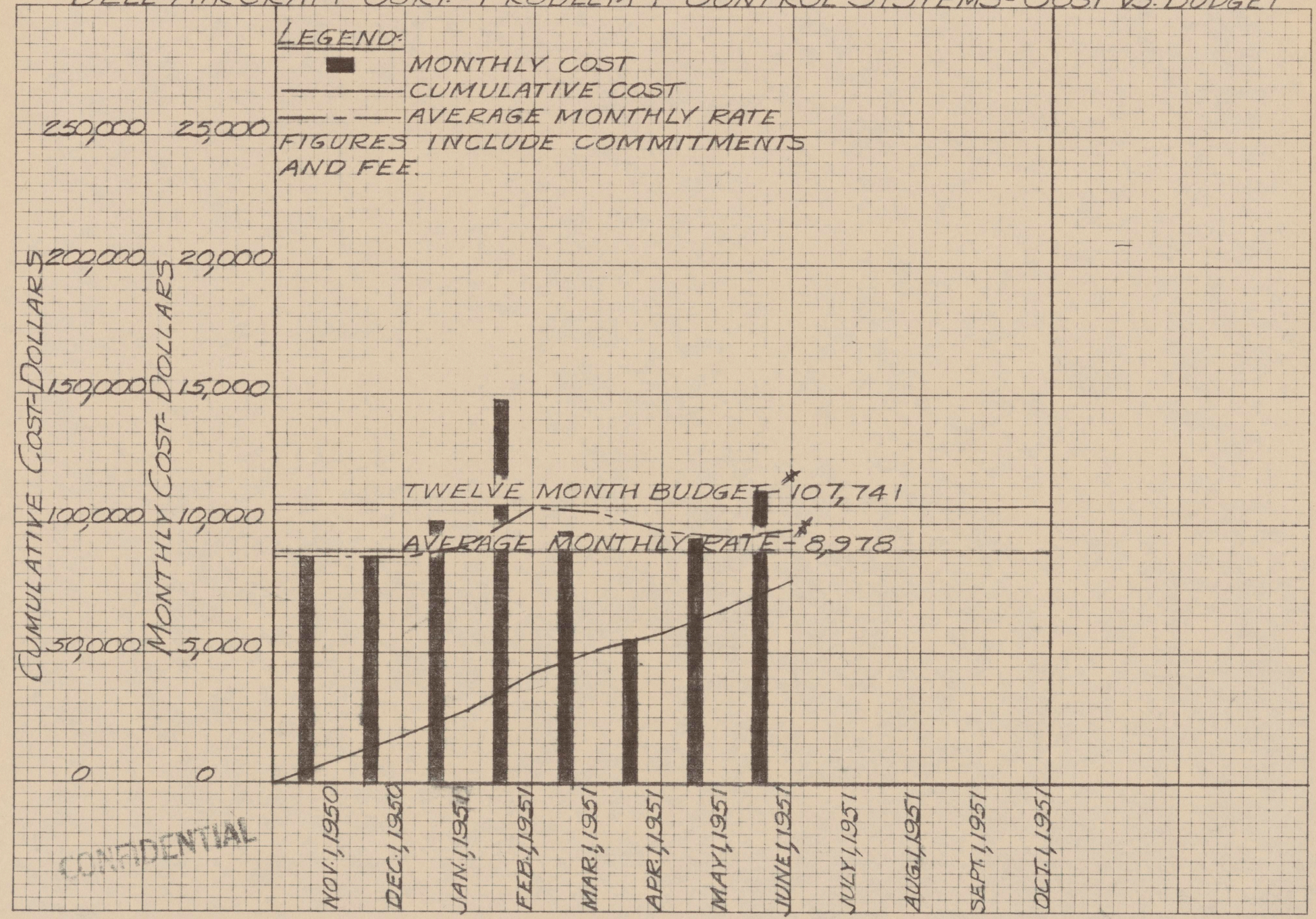
PROJECT METEOR

BELL AIRCRAFT CORP.- PROBLEM 4 - CONTROL SYSTEMS - COST VS. BUDGET



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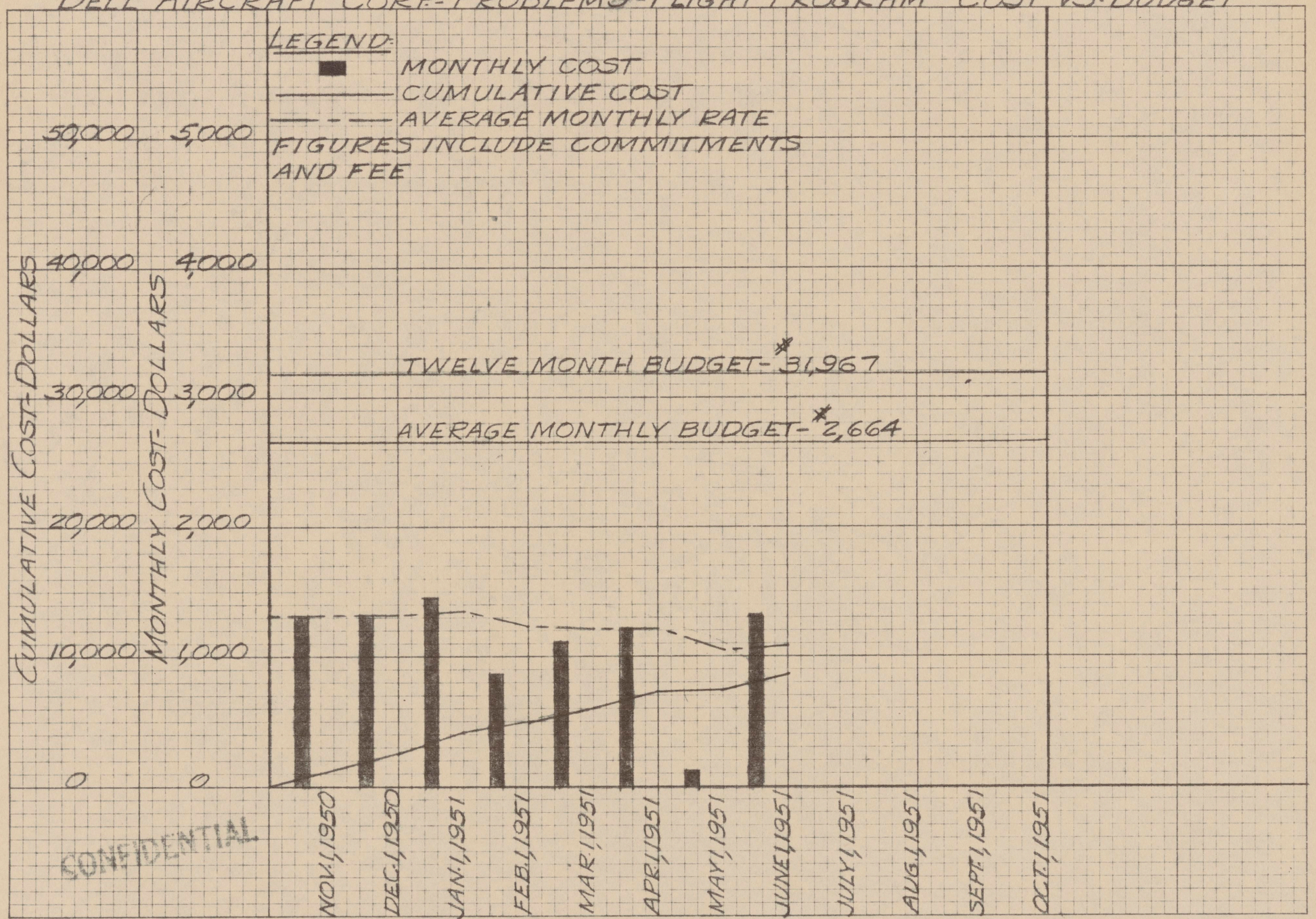
PROJECT METEOR

BELL AIRCRAFT CORP.- PROBLEM 5 - FLIGHT PROGRAM - COST VS. BUDGET



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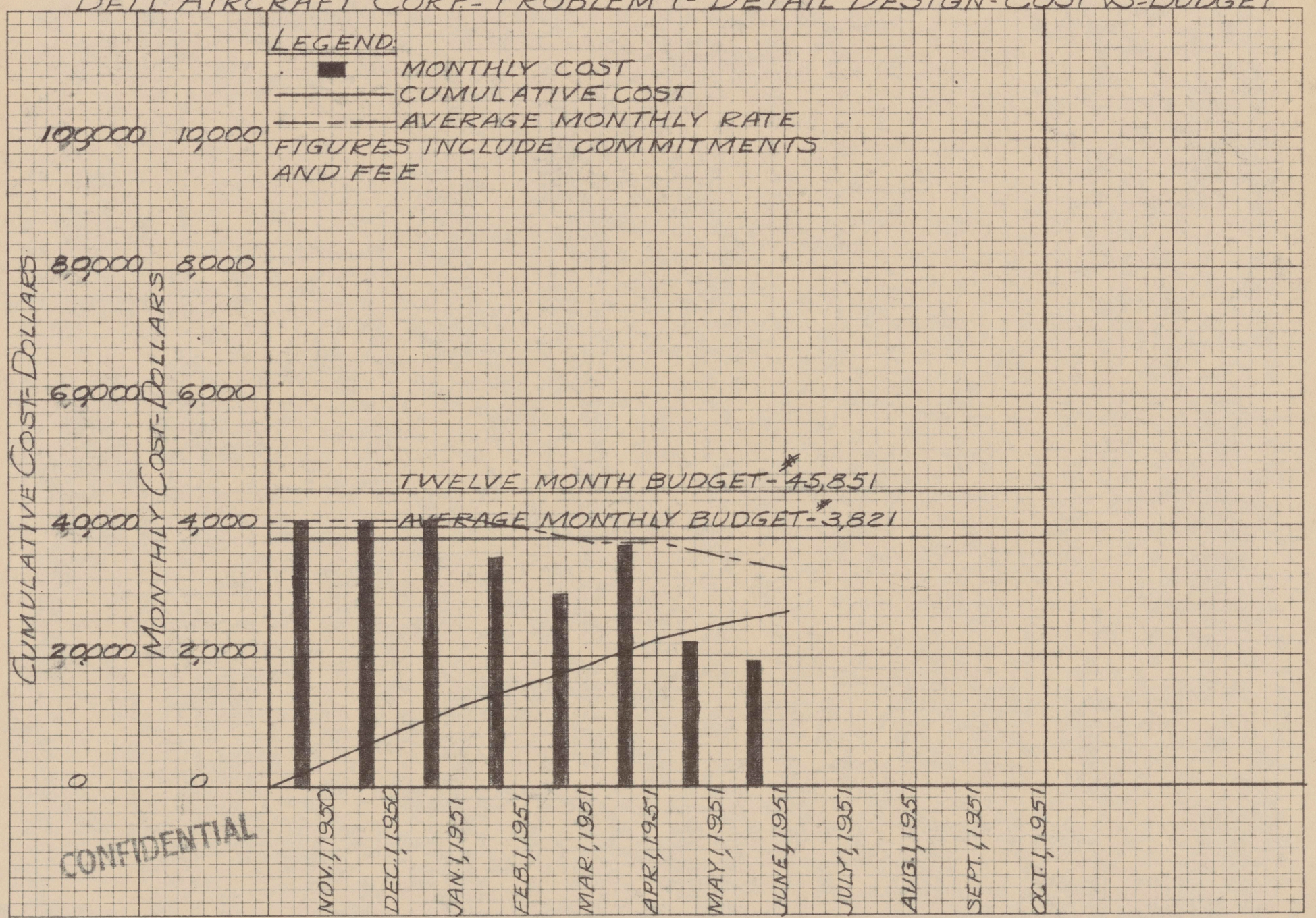
25

PROJECT METEOR

BELL AIRCRAFT CORP.- PROBLEM 7- DETAIL DESIGN- COST VS. BUDGET



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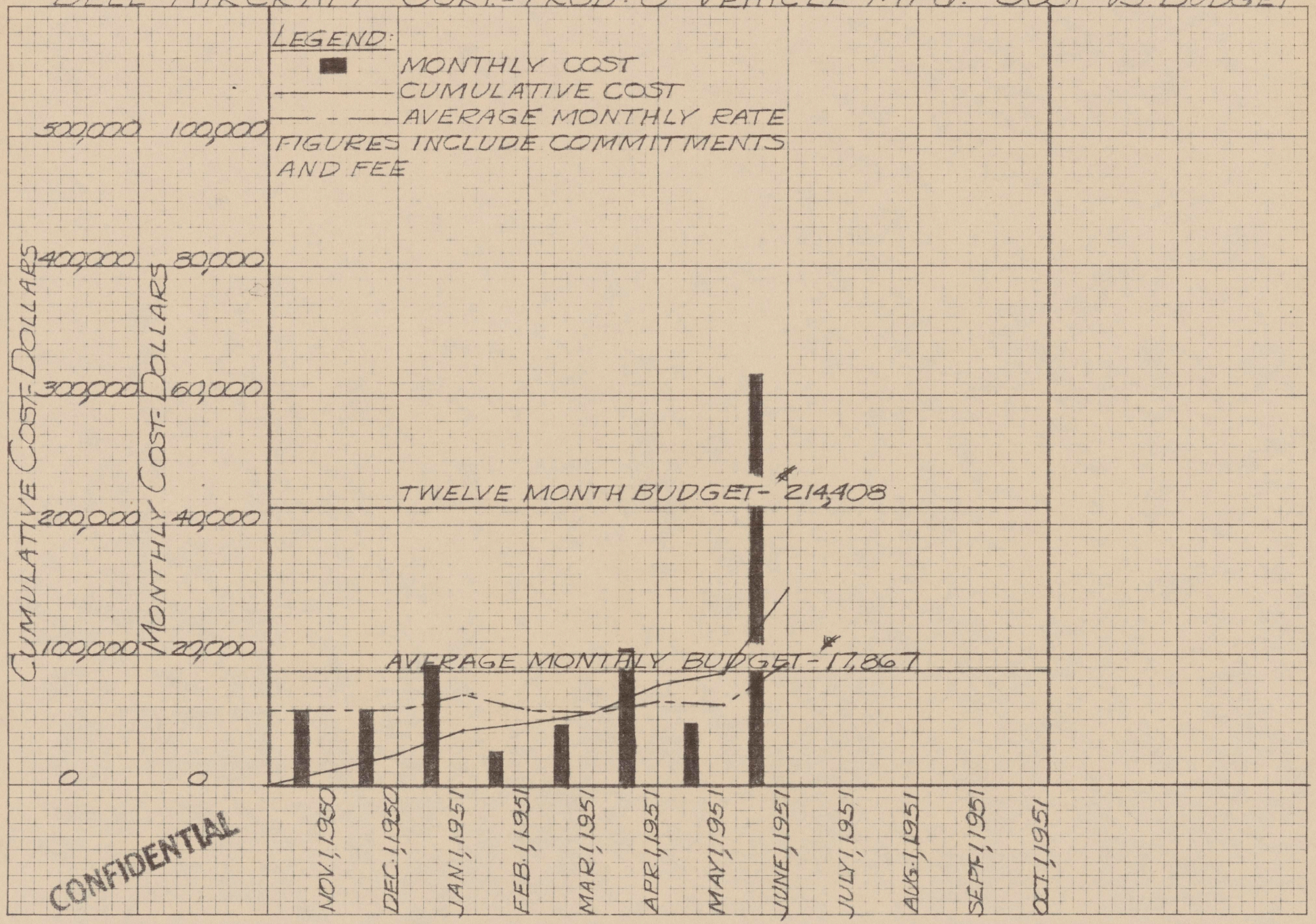
PROJECT METEOR

BELL AIRCRAFT CORP.-PROB. 8-VEHICLE MFG.-COST VS. BUDGET



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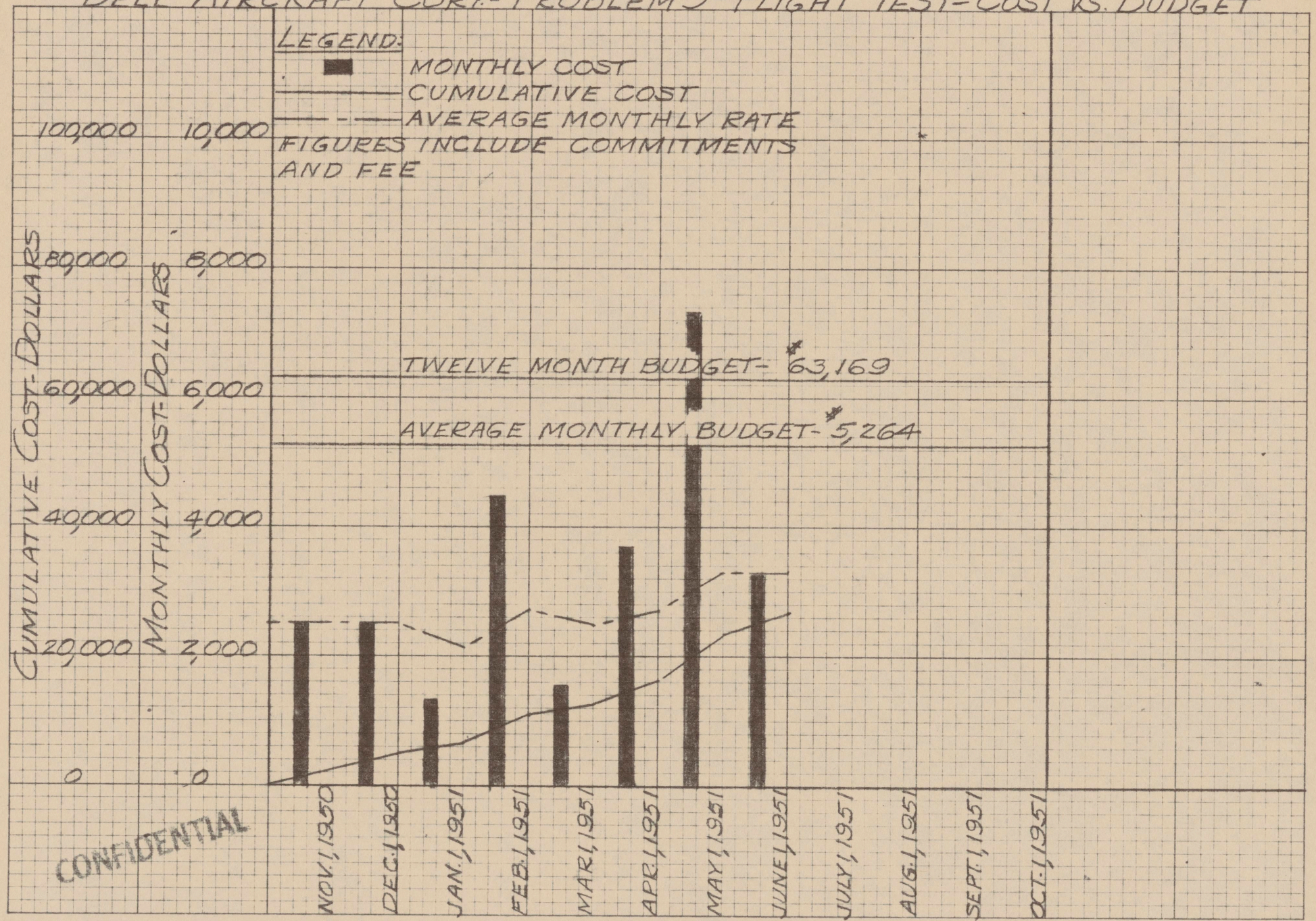
PROJECT METEOR

BELL AIRCRAFT CORP.- PROBLEM 9- FLIGHT TEST- COST VS. BUDGET



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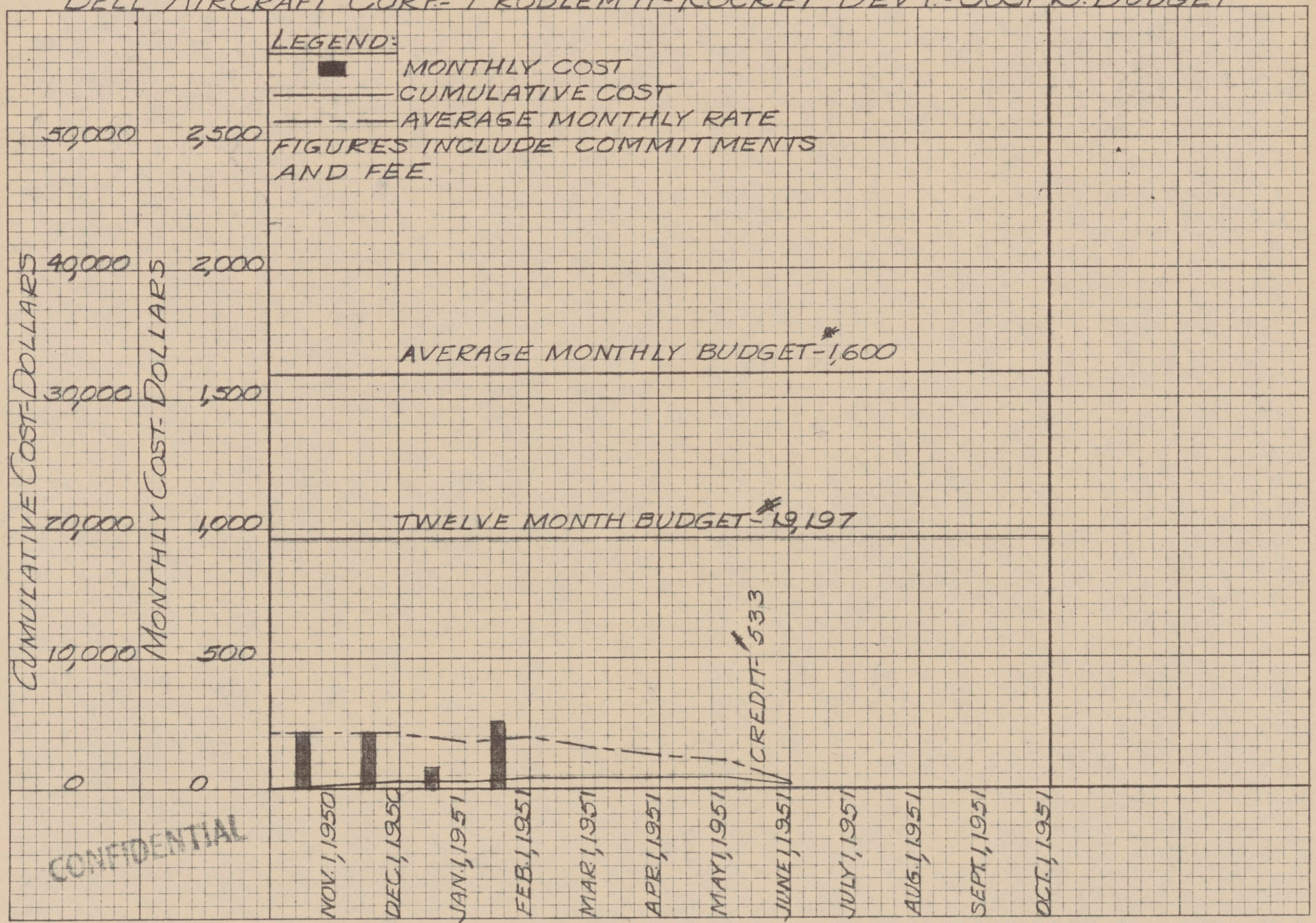
PROJECT METEOR

BELL AIRCRAFT CORP- PROBLEM II-ROCKET DEV'T.-COST VS. BUDGET



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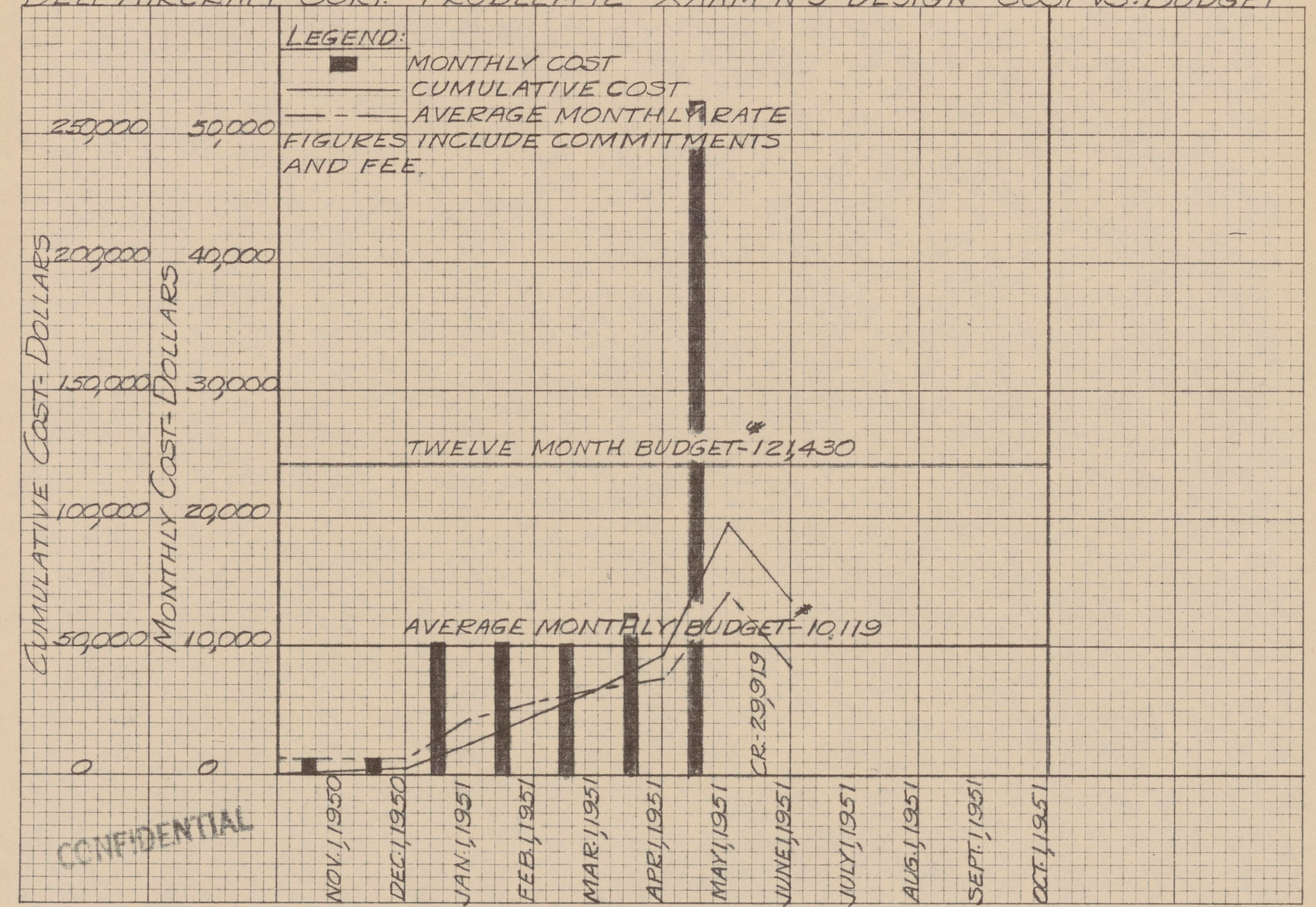
PROJECT METEOR

BELL AIRCRAFT CORP.- PROBLEM 12- XAAM-N-5 DESIGN- COST VS. BUDGET



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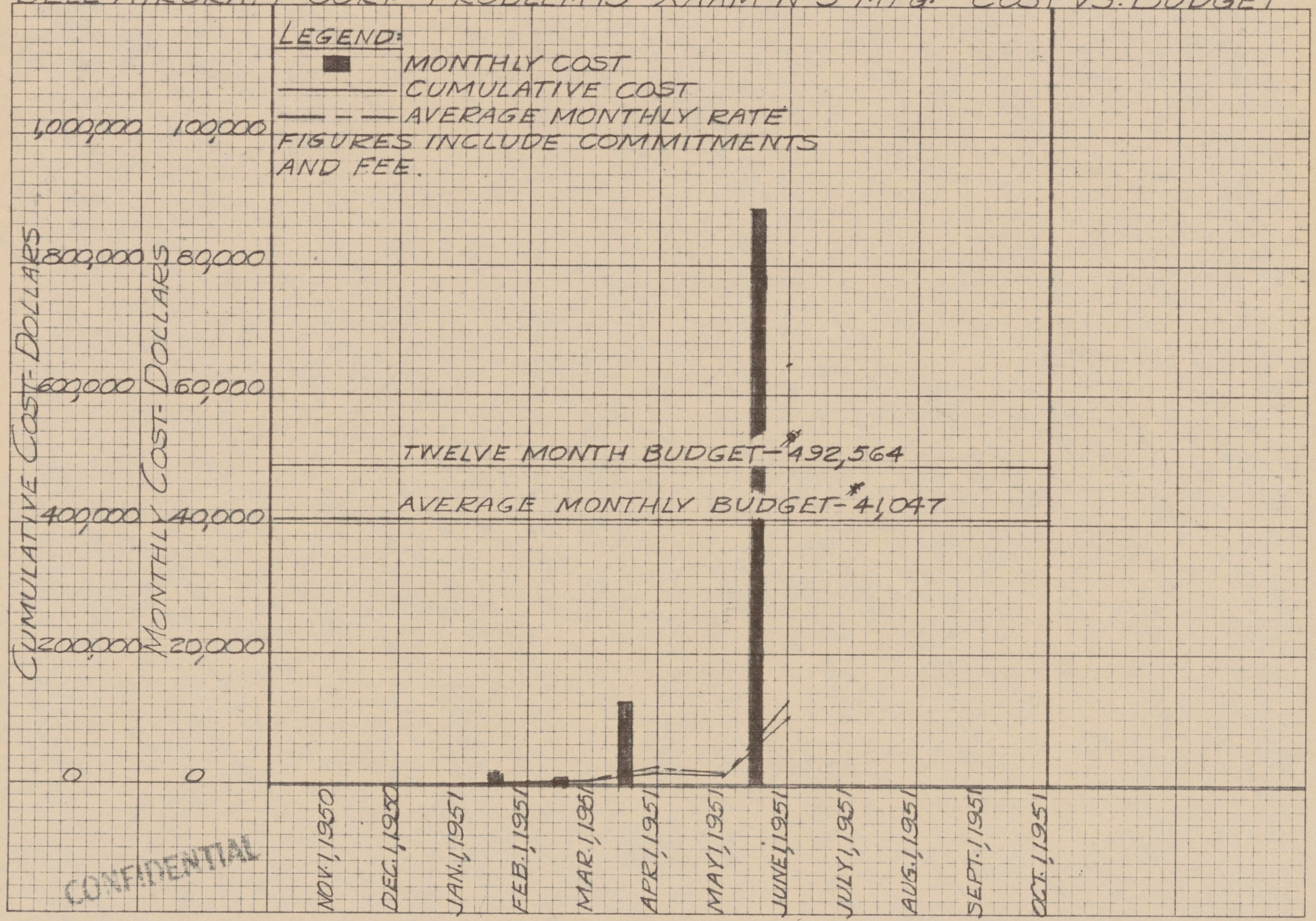
CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

PROJECT METEOR

BELL AIRCRAFT CORP.- PROBLEM 13- XAAM-N-5 MFG.- COST VS. BUDGET



CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

#1

PROJECT METEOR

PROJECT TOTAL ——— COST VS. BUDGET

LEGEND:
- ■ MONTHLY COST
- ——— CUMULATIVE COST
- — - — AVERAGE MONTHLY RATE

FIGURES INCLUDE COMMITMENTS AND FEE.

*NOTE: M.I.T. BUDGET RUNS TO 9-1-51
FEDERAL BUDGET TO 12-1-51

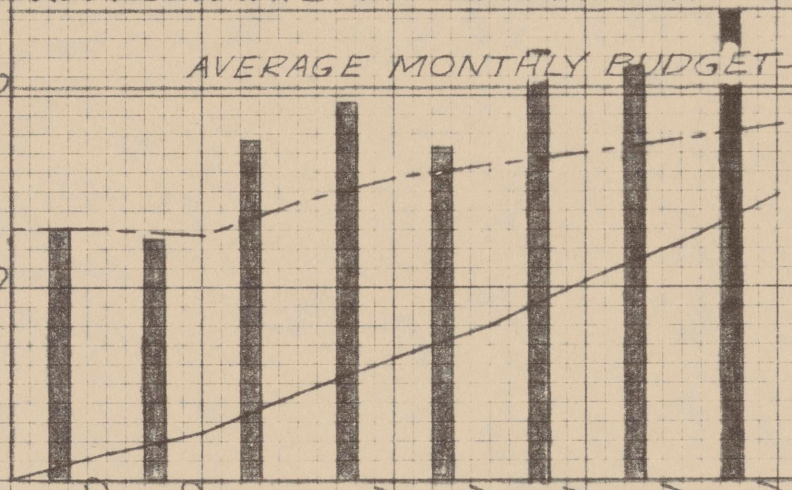
REVISED 6-15-51 TO INCREASE BUDGET

CUMULATIVE COST-DOLLARS
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
0

MONTHLY COST-DOLLARS
1,000,000
800,000
600,000
400,000
200,000
0

APPROXIMATE TWELVE MONTH BUDGET-*4,932,803*

AVERAGE MONTHLY BUDGET-*411,067*



NOV.1,1950
DEC.1,1950
JAN.1,1951
FEB.1,1951
MAR.1,1951
APR.1,1951
MAY.1,1951
JUNE.1,1951
JULY.1,1951
AUG.1,1951
SEPT.1,1951
OCT.1,1951

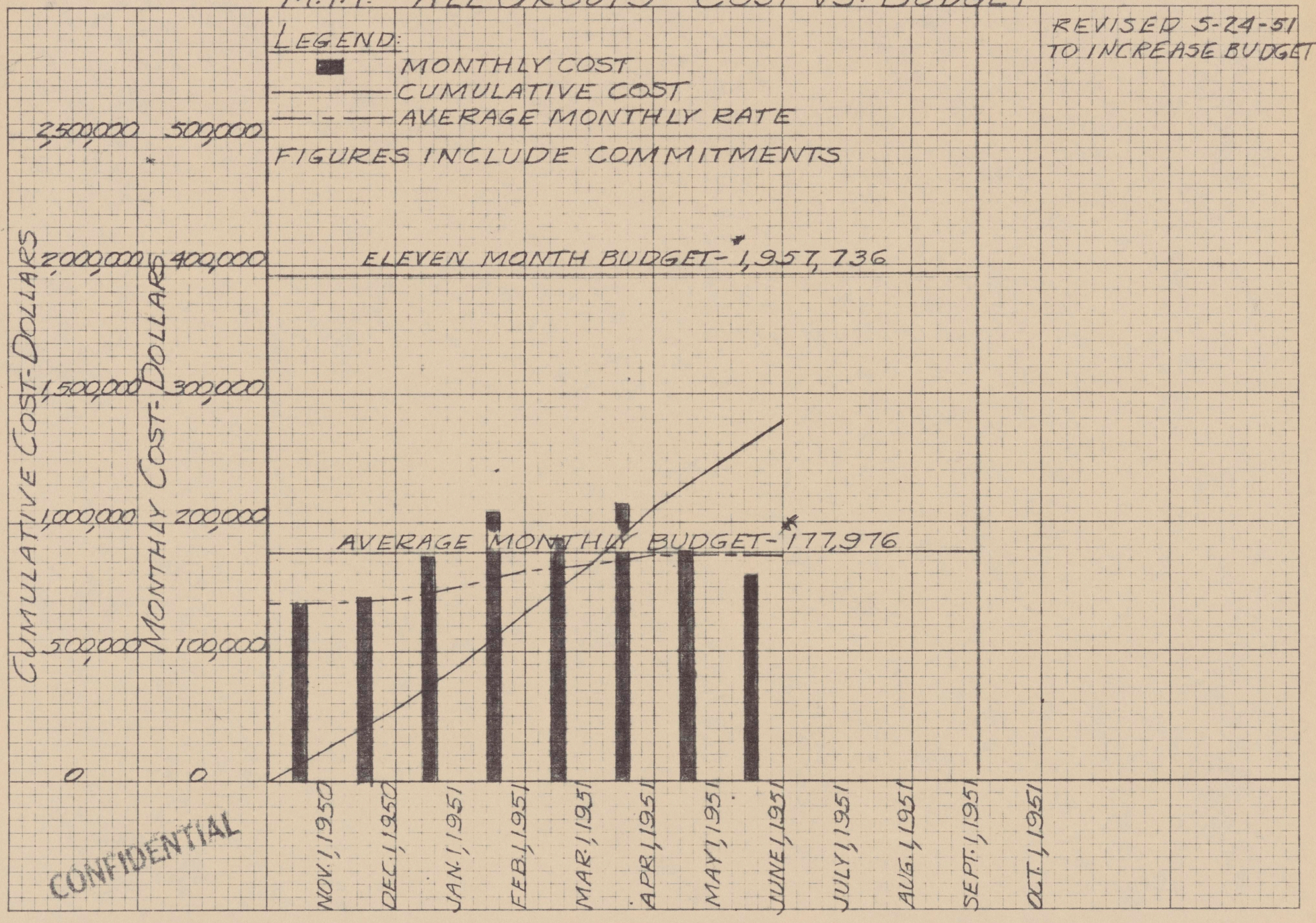
CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

2

PROJECT METEOR

M.I.T. - ALL GROUPS - COST VS. BUDGET



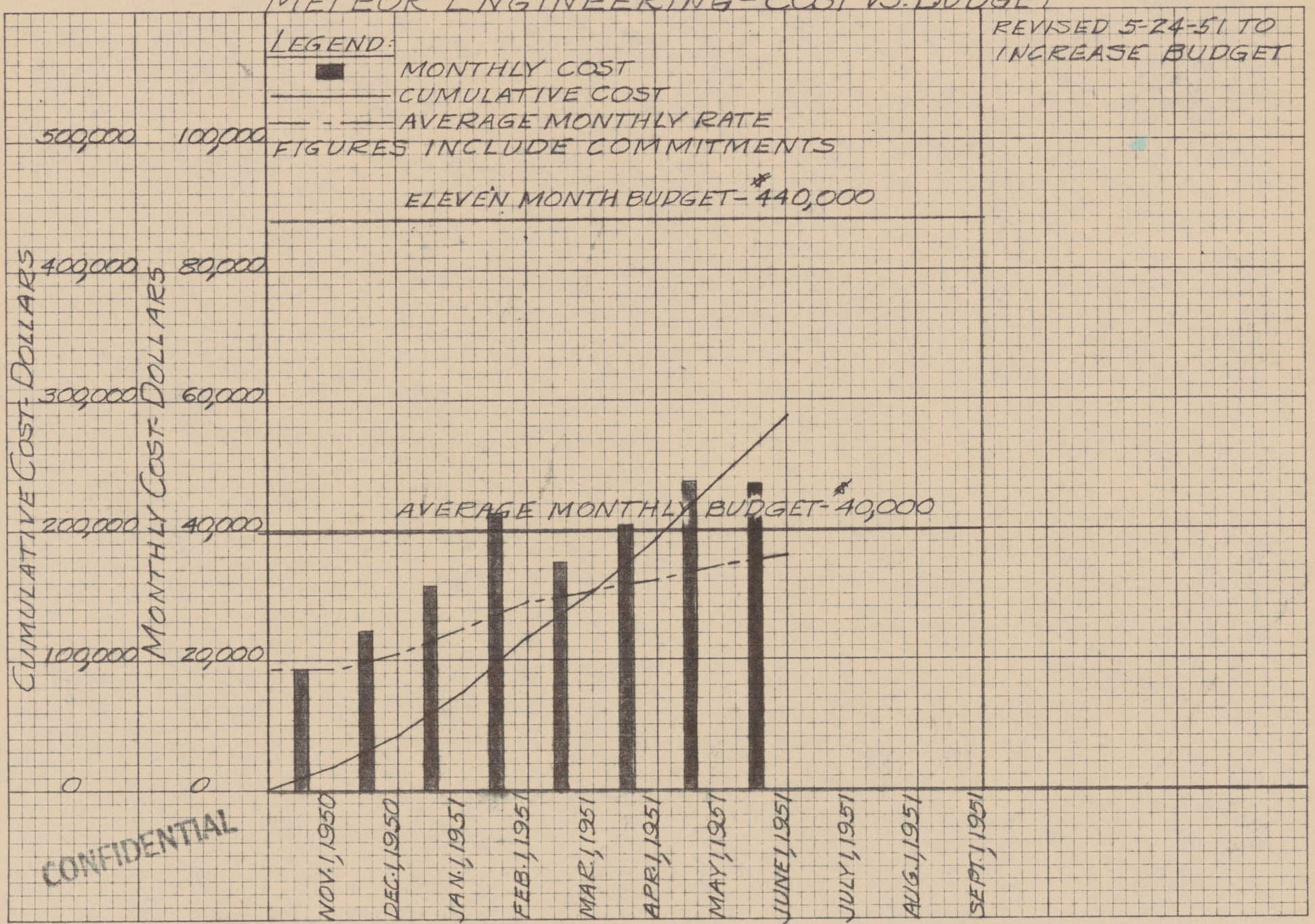
CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

3

PROJECT METEOR

METEOR ENGINEERING - COST VS. BUDGET

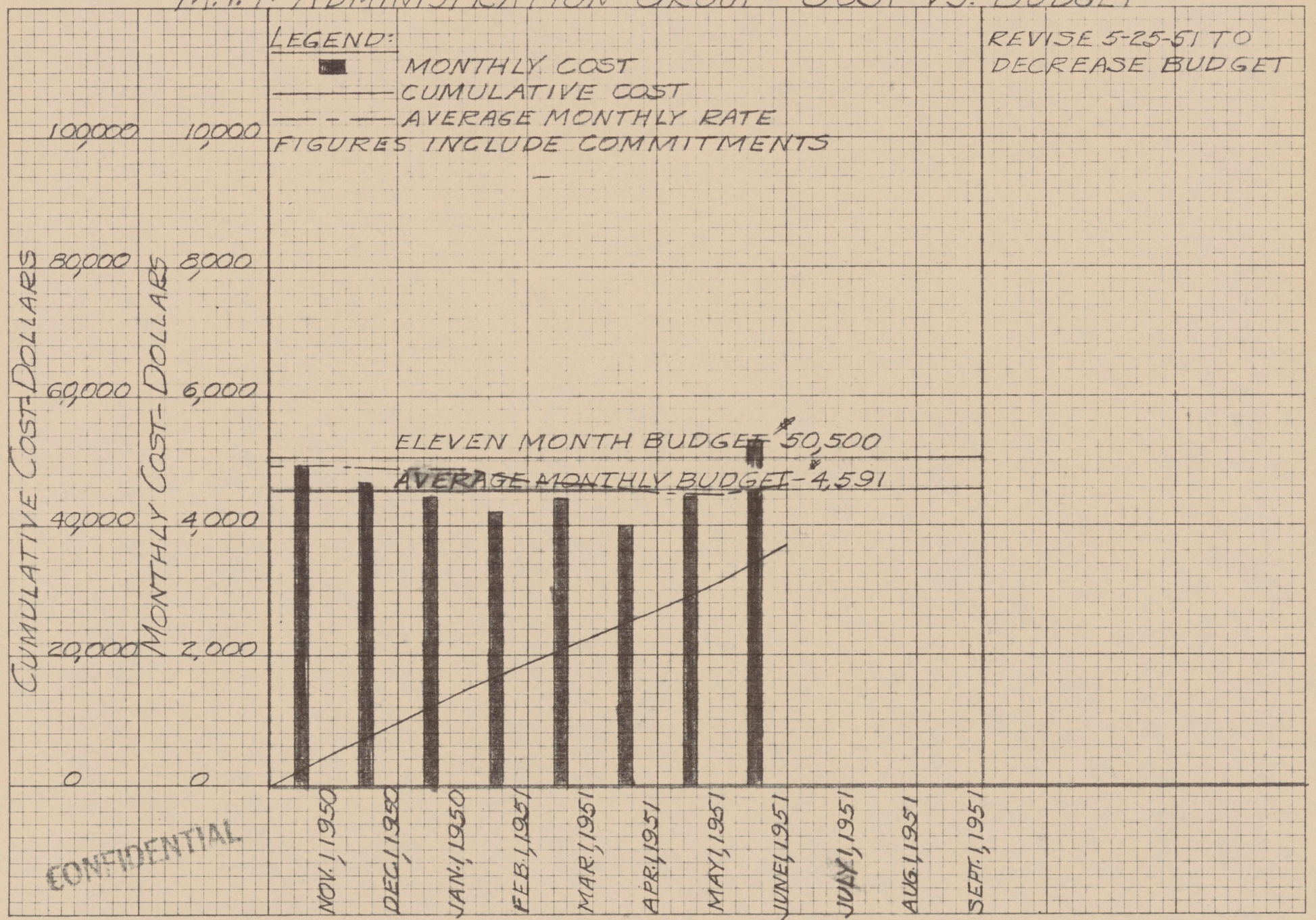


CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

PROJECT METEOR

M.I.T. ADMINISTRATION GROUP - COST VS. BUDGET



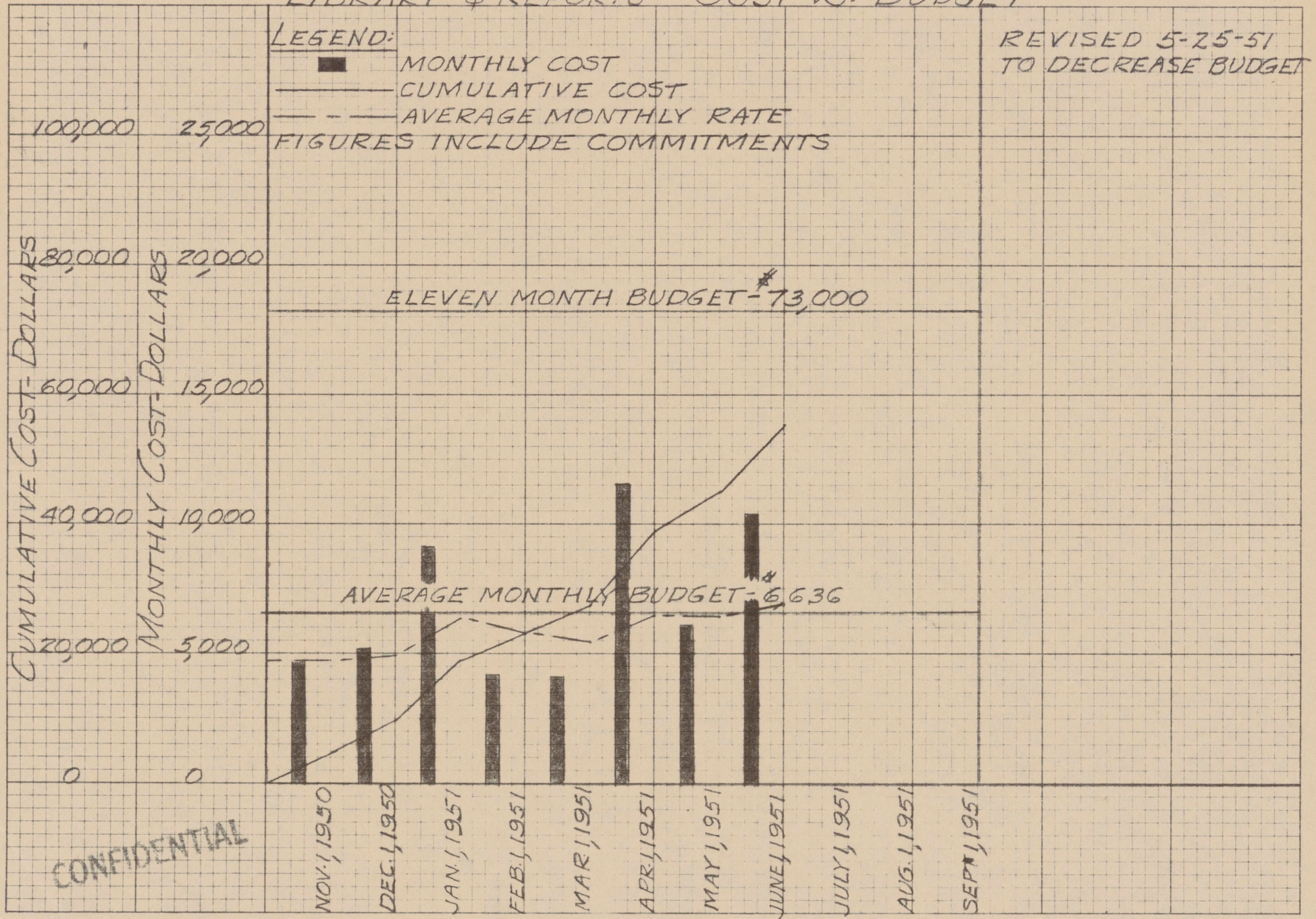
CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

5

PROJECT METEOR

LIBRARY & REPORTS - COST VS. BUDGET

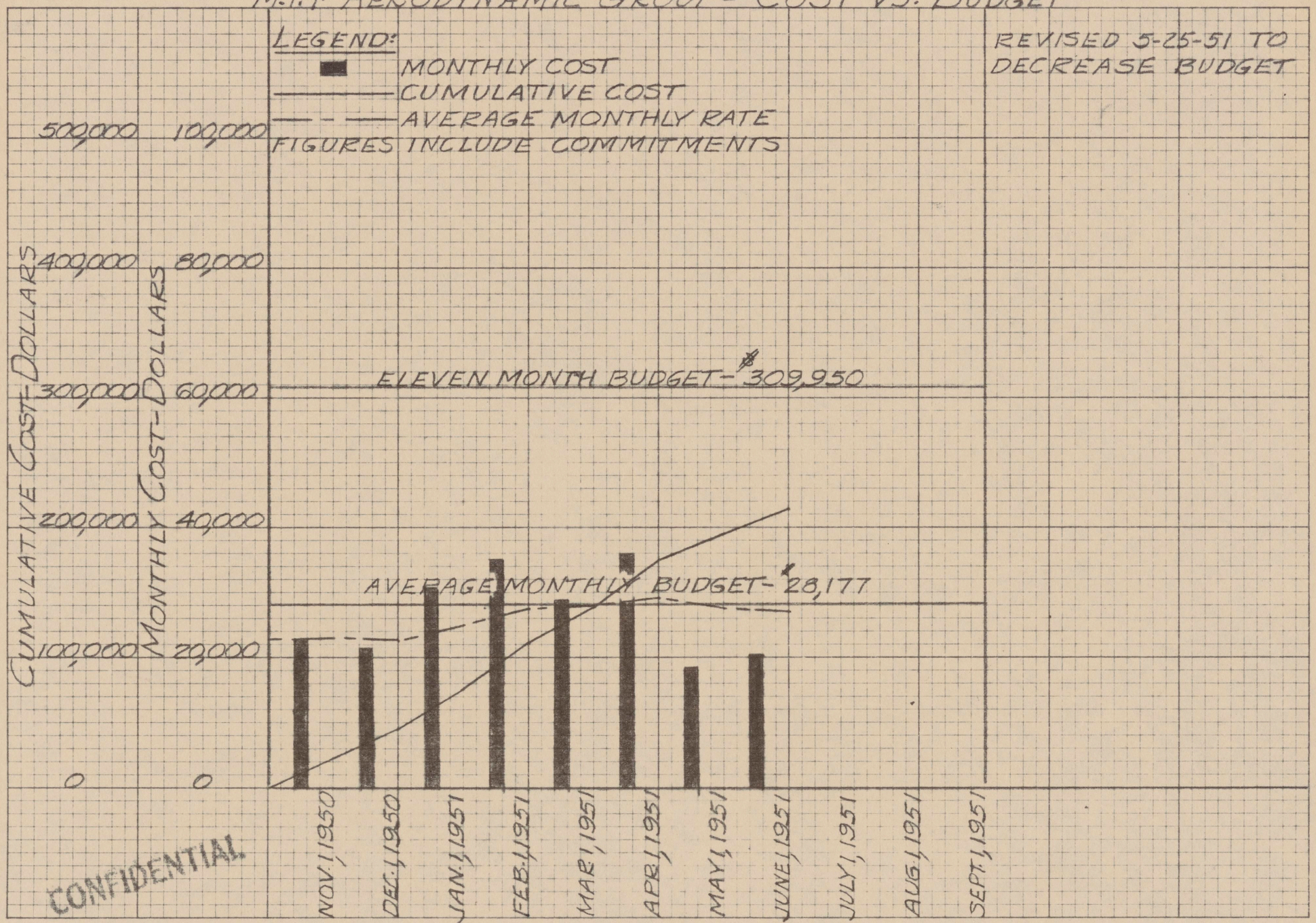


CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

PROJECT METEOR

M.I.T. AERODYNAMIC GROUP - COST VS. BUDGET



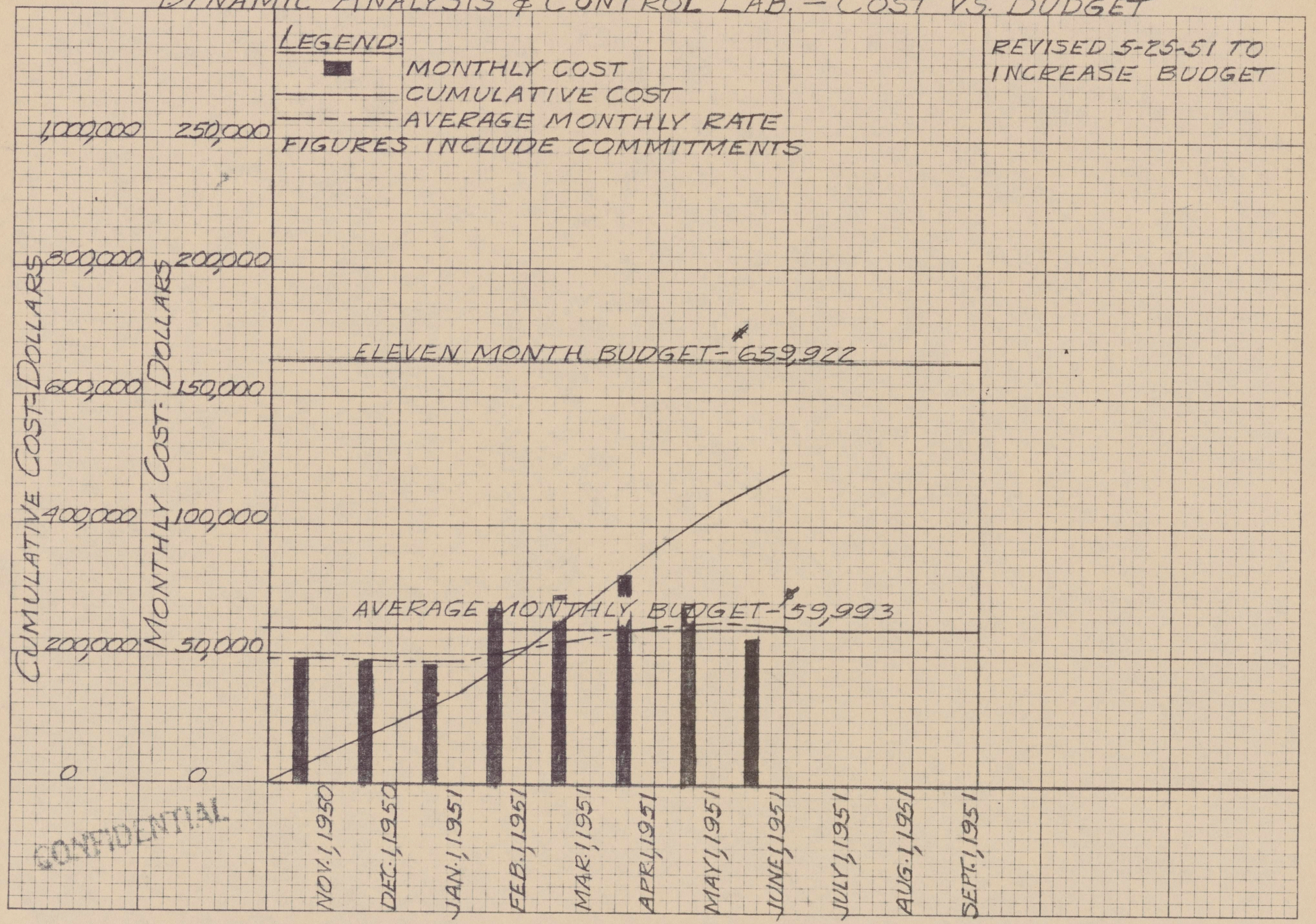
CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS.

CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

PROJECT METEOR

DYNAMIC ANALYSIS & CONTROL LAB. – COST VS. BUDGET



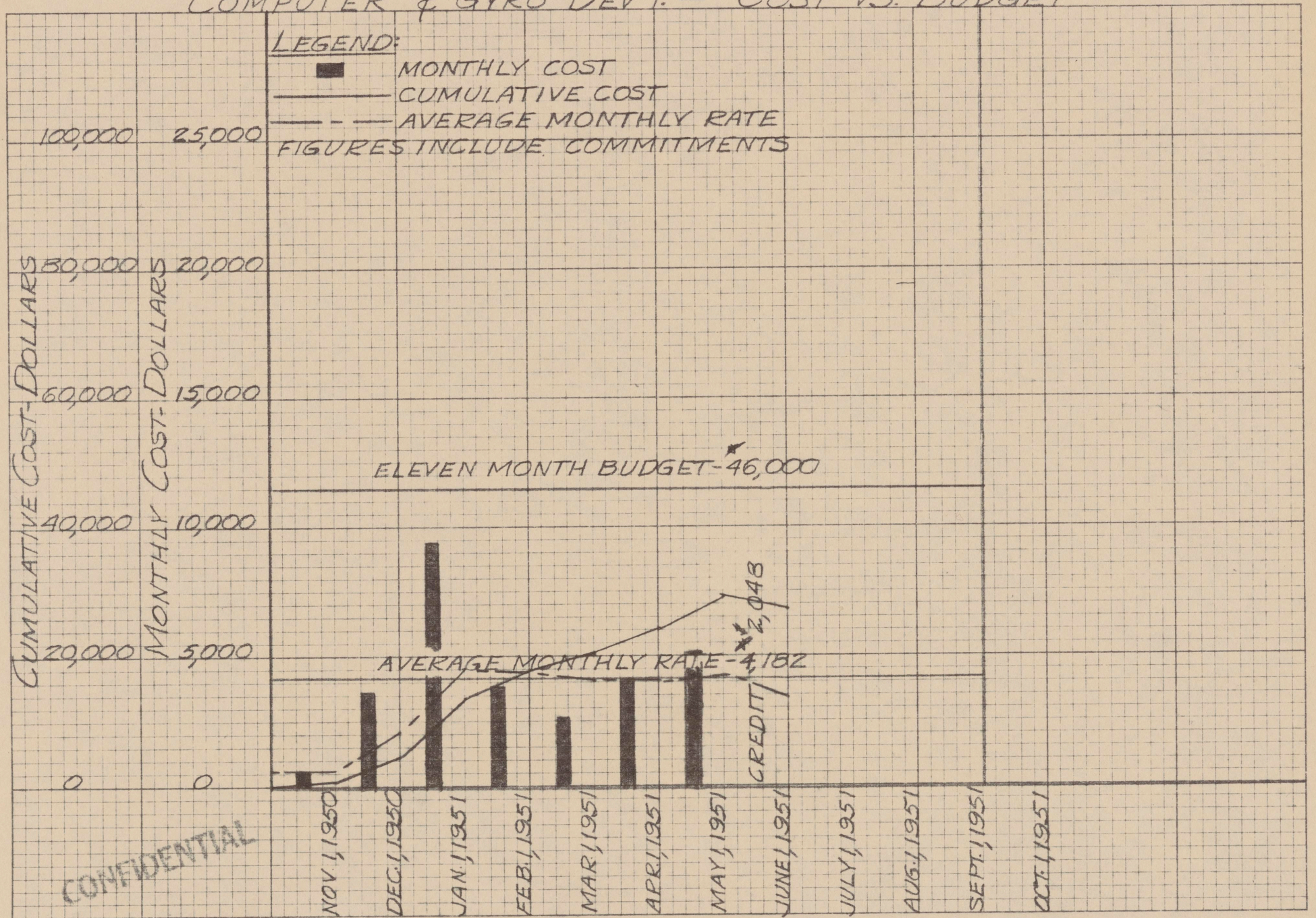
CONFIDENTIAL

NO. 31.190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

8

PROJECT METEOR

COMPUTER & GYRO DEV'T. — COST VS. BUDGET



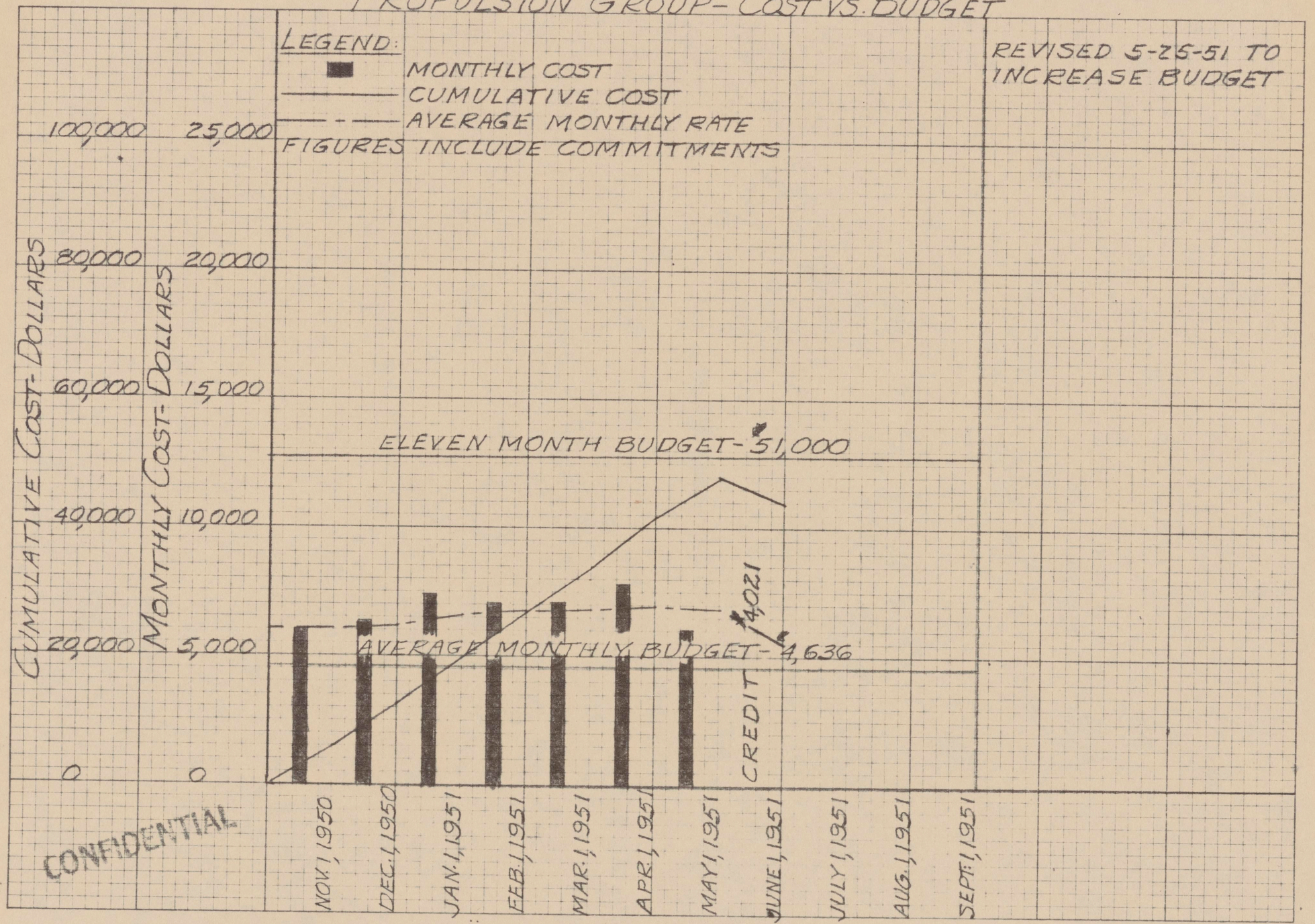
CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS.
CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

9

PROJECT METEOR

PROPULSION GROUP - COST VS. BUDGET



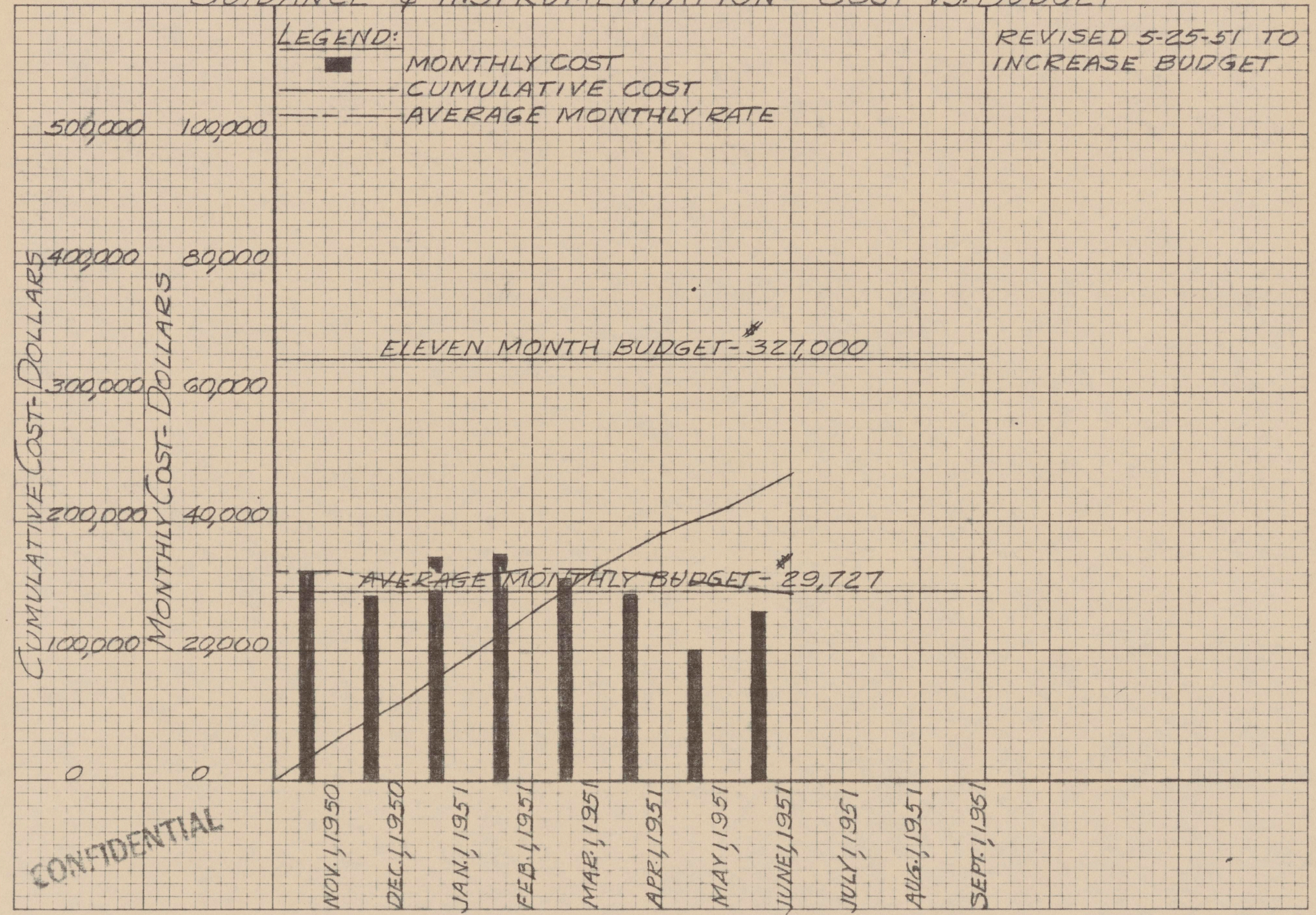
CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

10

PROJECT METEOR

GUIDANCE & INSTRUMENTATION - COST VS. BUDGET



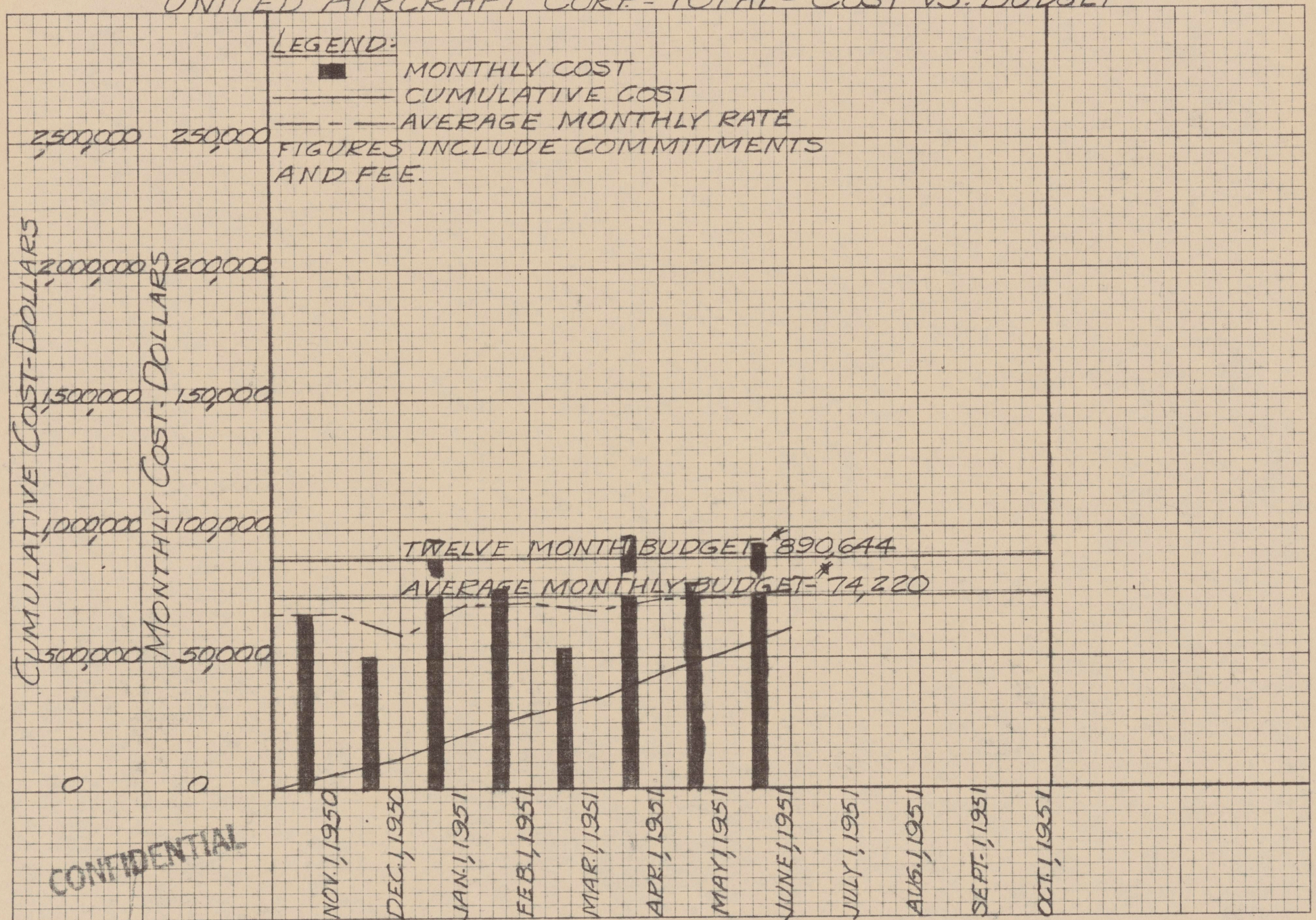
CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

11

PROJECT METEOR

UNITED AIRCRAFT CORP. - TOTAL - COST VS. BUDGET



CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

12

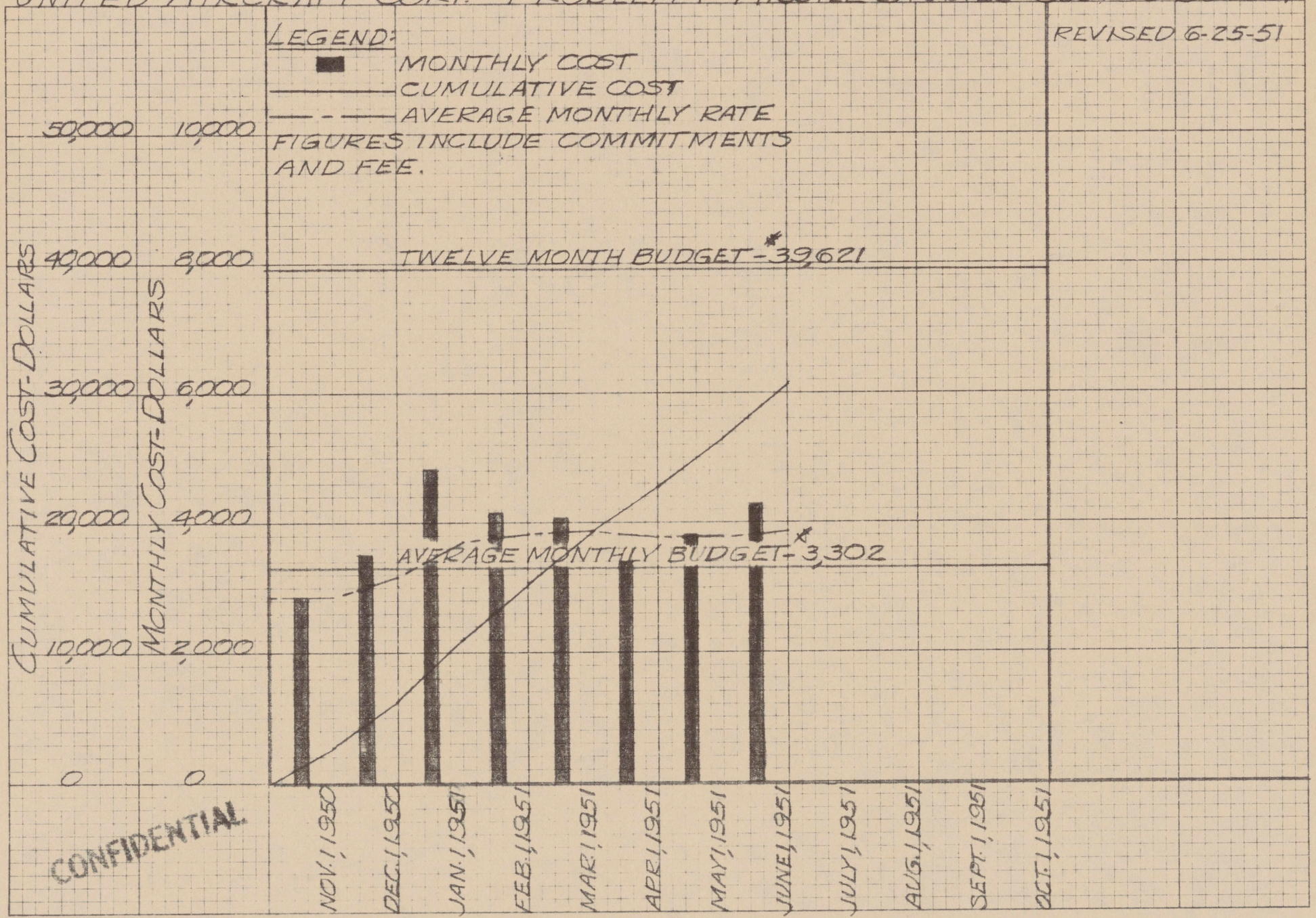
PROJECT METEOR

UNITED AIRCRAFT CORP.- PROBLEM 7-MISSILE STUDIES- COST VS. BUDGET

REVISED 6-25-51

LEGEND:
- MONTHLY COST
- CUMULATIVE COST
- AVERAGE MONTHLY RATE

FIGURES INCLUDE COMMITMENTS AND FEE.



CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

13

PROJECT METEOR

UNITED AIRCRAFT CORP. - PROBLEM 8 - BURNER DEV'T. - COST VS. BUDGET

REVISED 6-26-51

LEGEND:
- MONTHLY COST
- CUMULATIVE COST
- AVERAGE MONTHLY RATE

FIGURES INCLUDE COMMITMENTS AND FEE.

CUMULATIVE COST - DOLLARS: 1,000,000; 800,000; 600,000; 400,000; 200,000; 0

MONTHLY COST - DOLLARS: 100,000; 80,000; 60,000; 40,000; 20,000; 0

TWELVE MONTH BUDGET - $510,636

AVERAGE MONTHLY BUDGET - 42,553

NOV. 1, 1950 | DEC. 1, 1950 | JAN. 1, 1951 | FEB. 1, 1951 | MAR. 1, 1951 | APR. 1, 1951 | MAY 1, 1951 | JUNE 1, 1951 | JULY 1, 1951 | AUG. 1, 1951 | SEPT. 1, 1951 | OCT. 1, 1951

CONFIDENTIAL

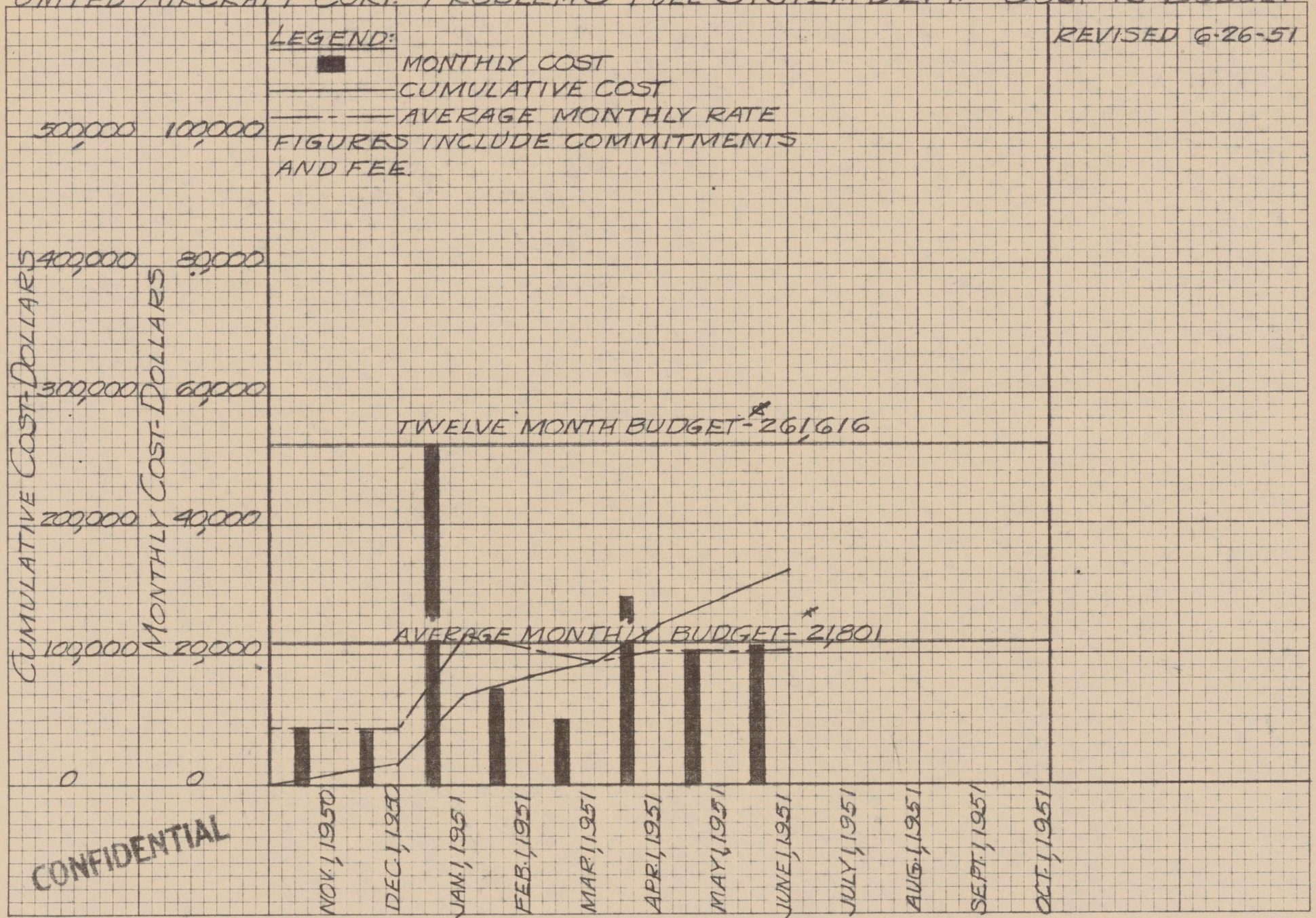
NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

14

PROJECT METEOR

UNITED AIRCRAFT CORP - PROBLEM 9 - FUEL SYSTEM DEV'T. - COST VS. BUDGET

REVISED 6-26-51

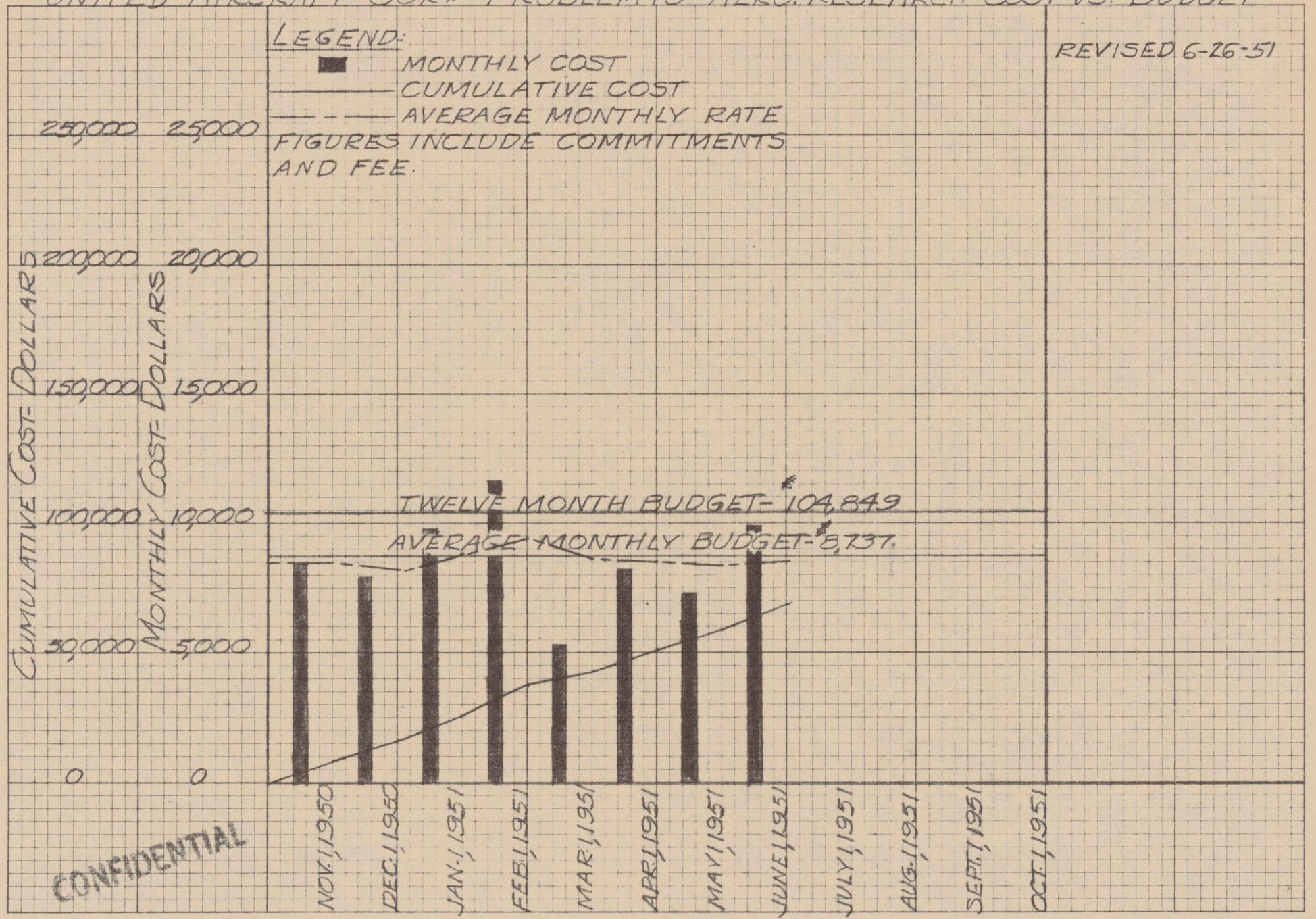


CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

PROJECT METEOR

UNITED AIRCRAFT CORP.- PROBLEM 10- AERO. RESEARCH- COST VS. BUDGET



CONFIDENTIAL

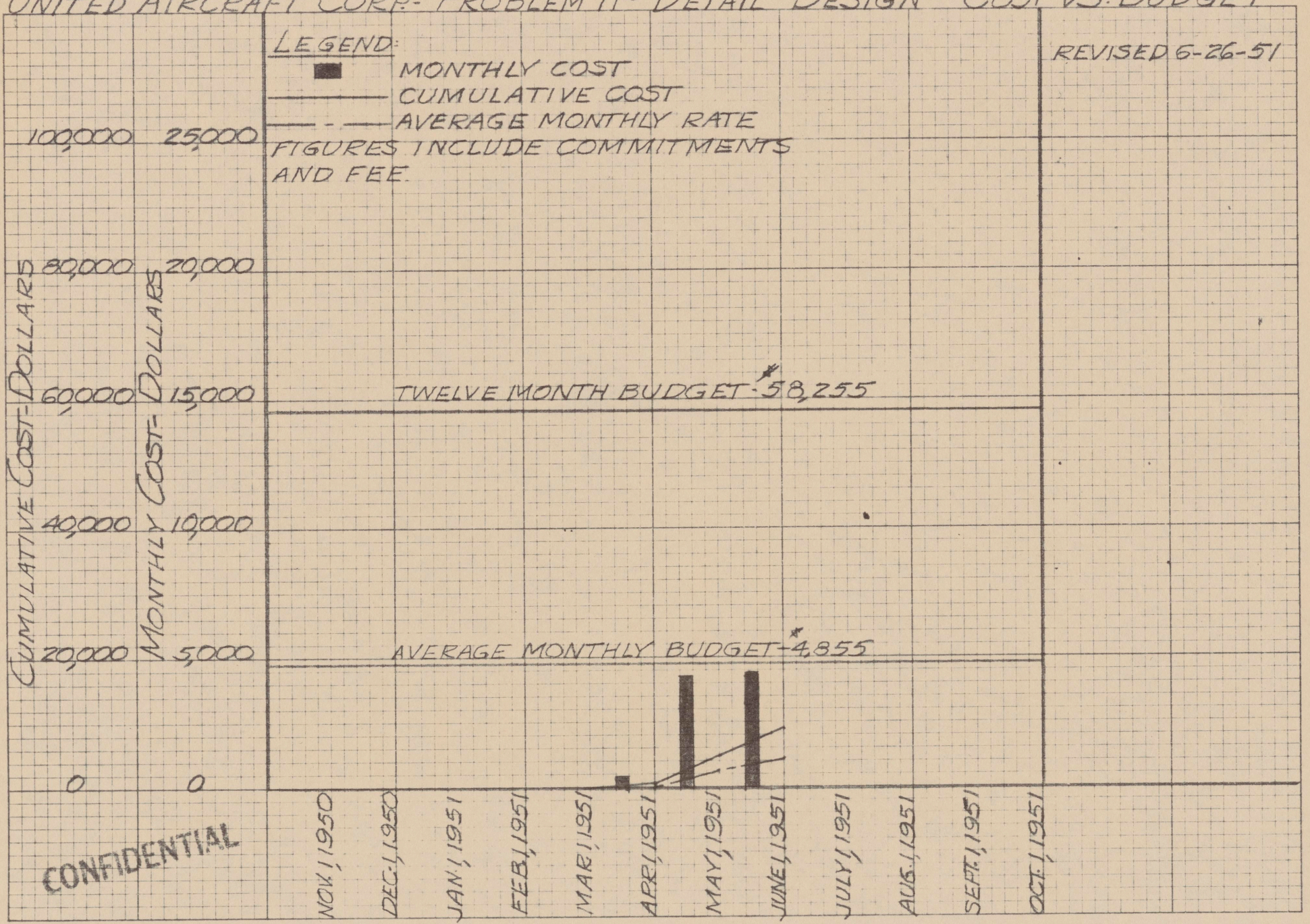
NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

16

PROJECT METEOR

UNITED AIRCRAFT CORP. - PROBLEM II - DETAIL DESIGN - COST VS. BUDGET

REVISED 6-26-51



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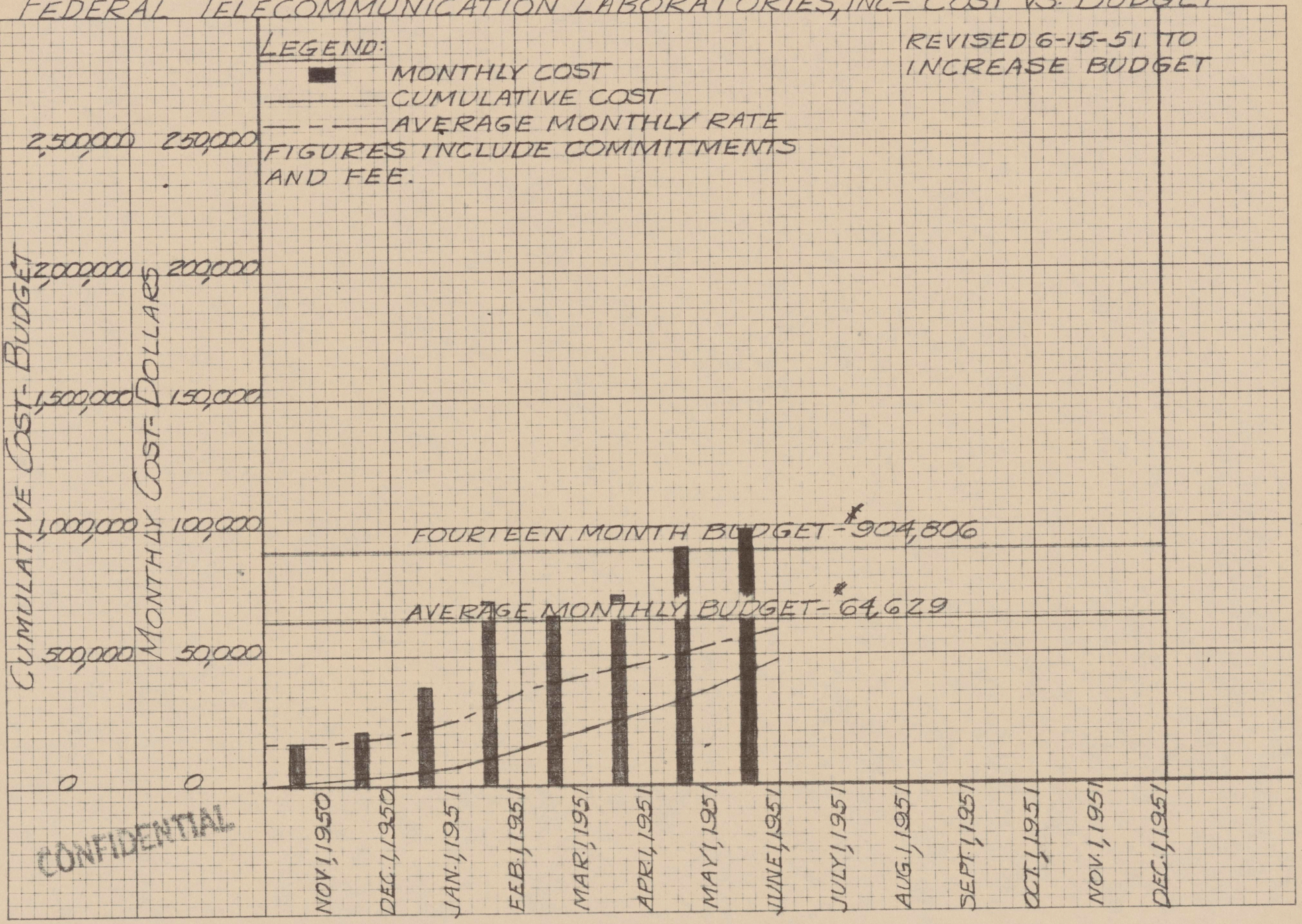
NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

PROJECT METEOR

FEDERAL TELECOMMUNICATION LABORATORIES, INC- COST VS. BUDGET



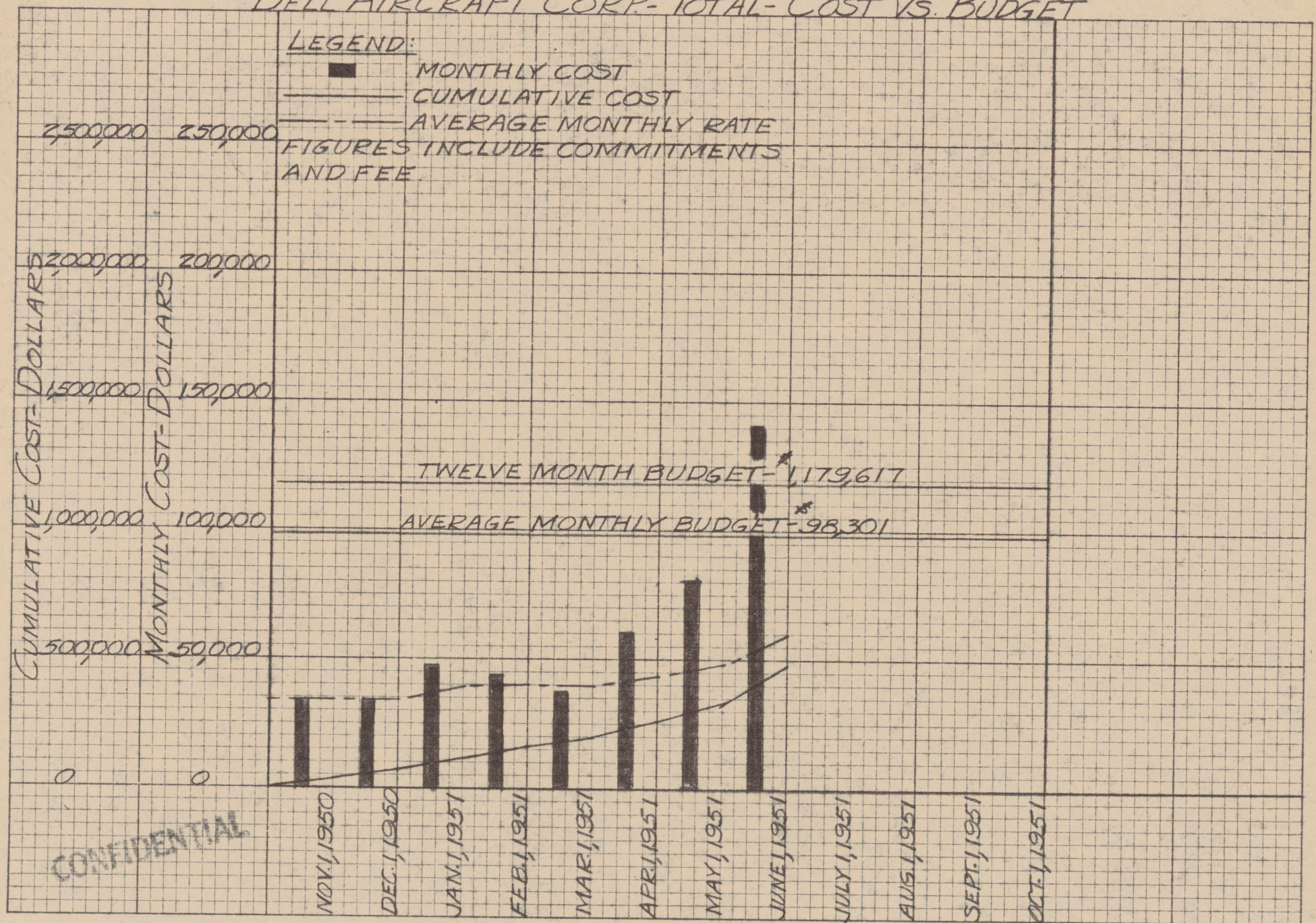
CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS.
CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

18

PROJECT METEOR

BELL AIRCRAFT CORP.- TOTAL- COST VS. BUDGET



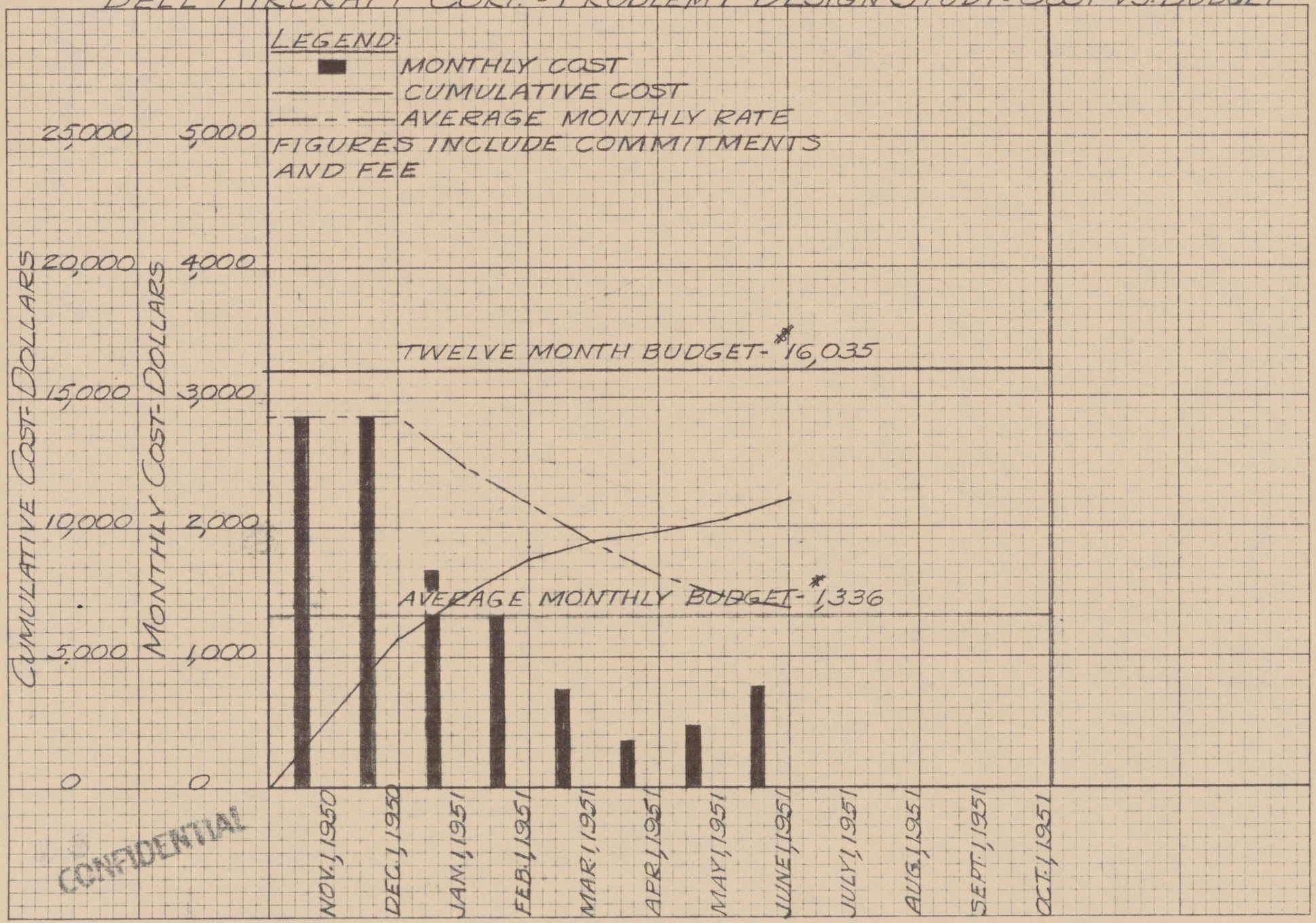
CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

19

PROJECT METEOR

BELL AIRCRAFT CORP. - PROBLEM I - DESIGN STUDY - COST VS. BUDGET

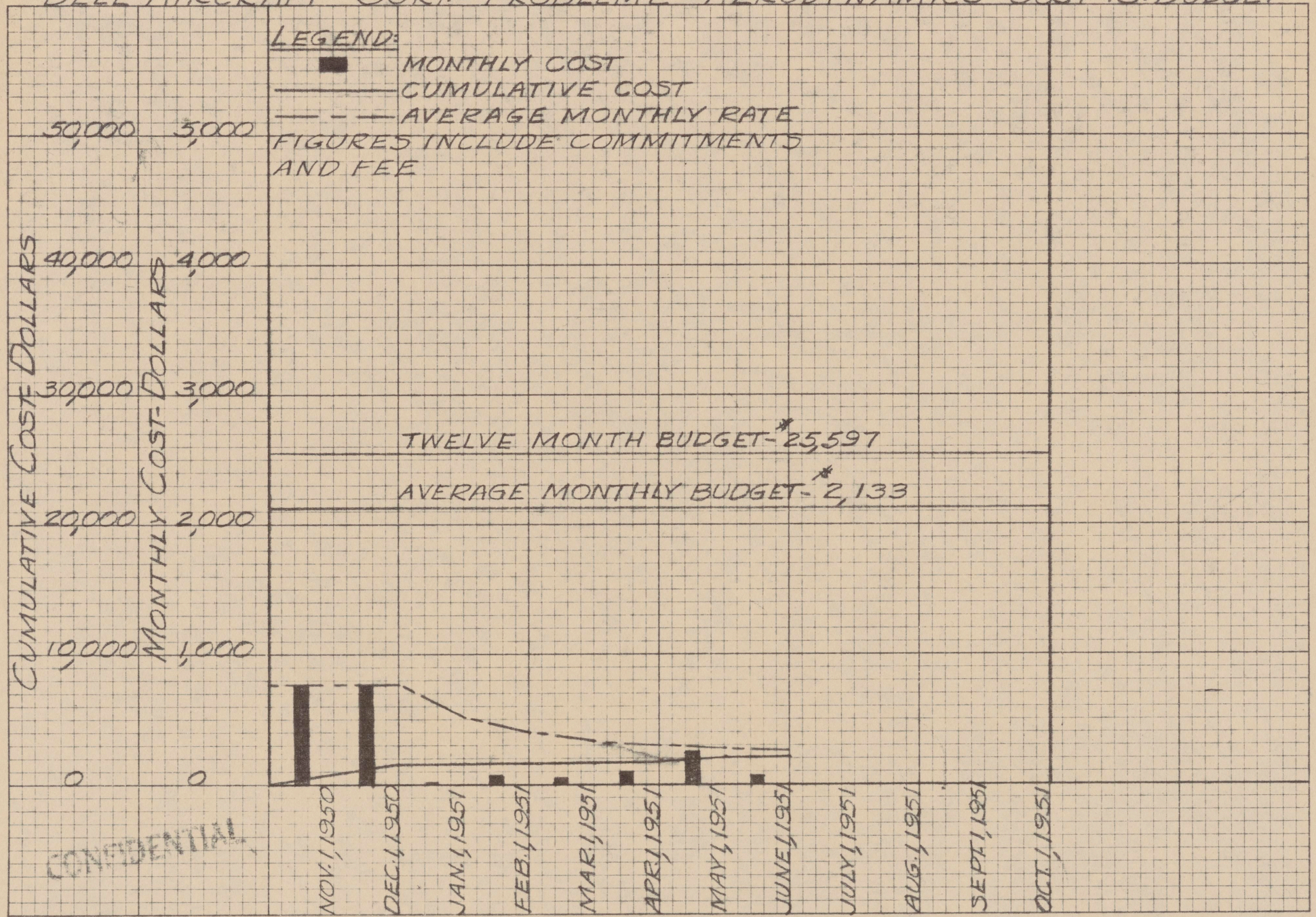


CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

PROJECT METEOR

BELL AIRCRAFT CORP.- PROBLEM 2 - AERODYNAMICS - COST VS. BUDGET

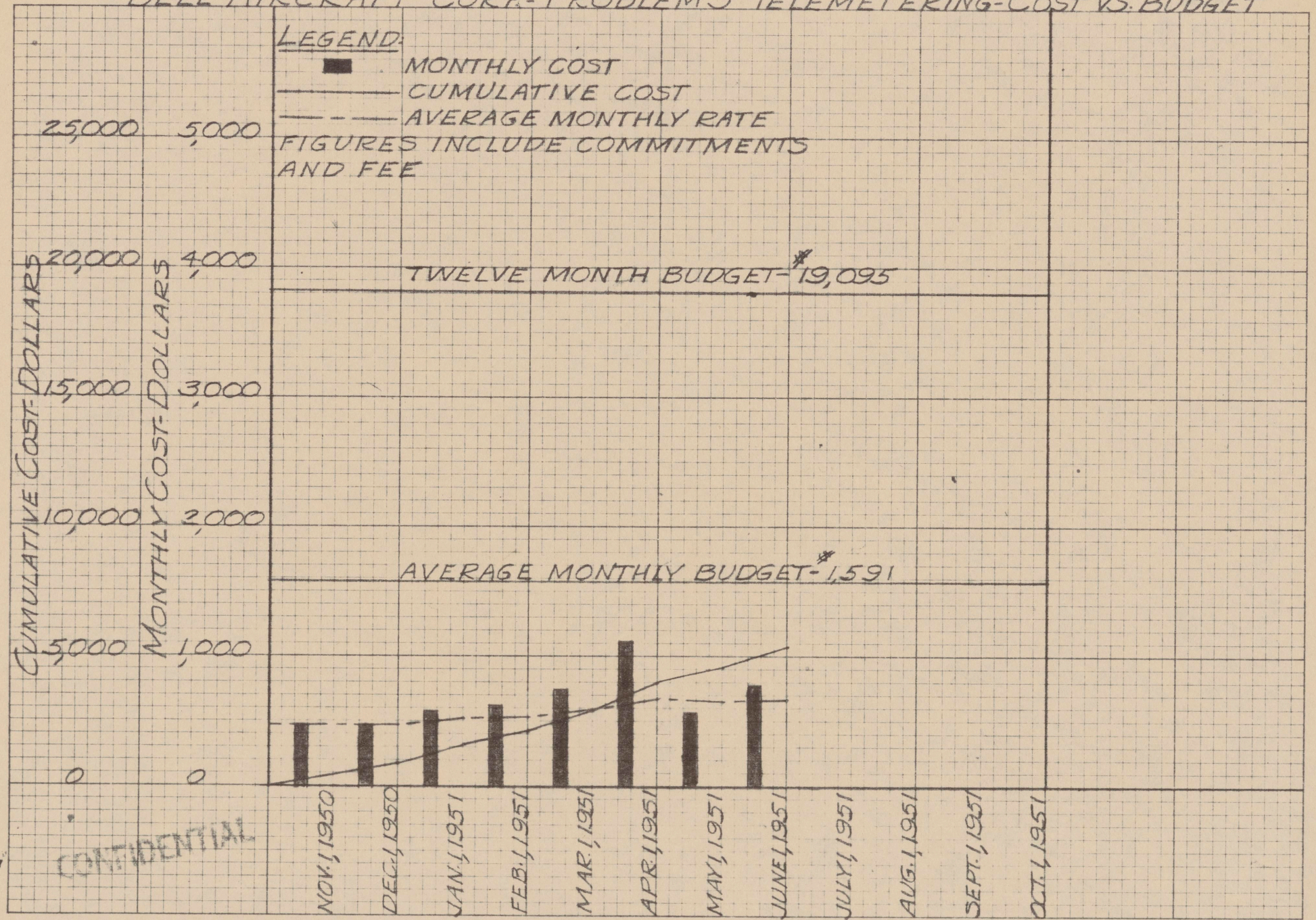


CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

PROJECT METEOR

BELL AIRCRAFT CORP - PROBLEM 3 - TELEMETERING - COST VS. BUDGET

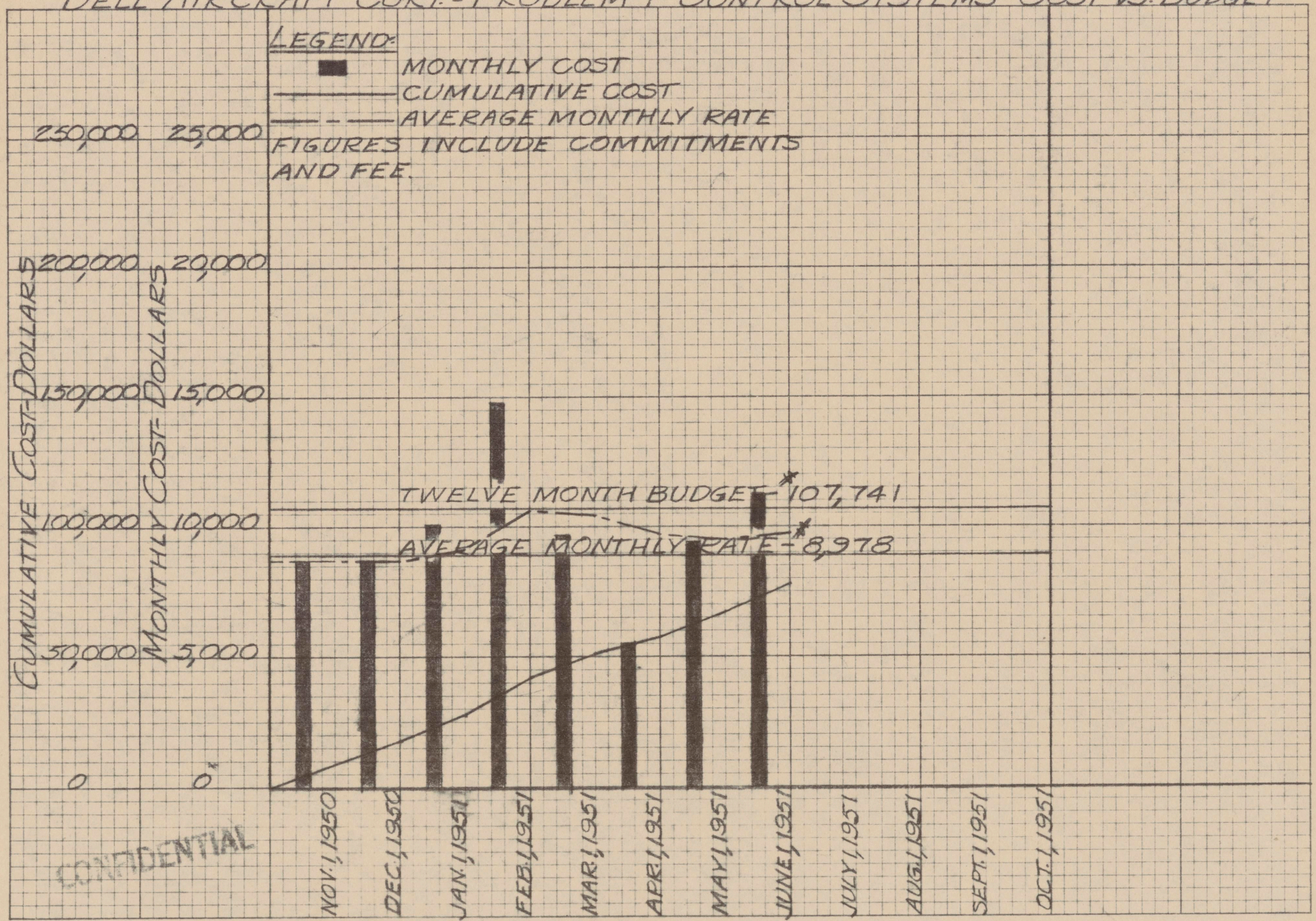


CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

PROJECT METEOR

BELL AIRCRAFT CORP.- PROBLEM 4 - CONTROL SYSTEMS - COST VS. BUDGET

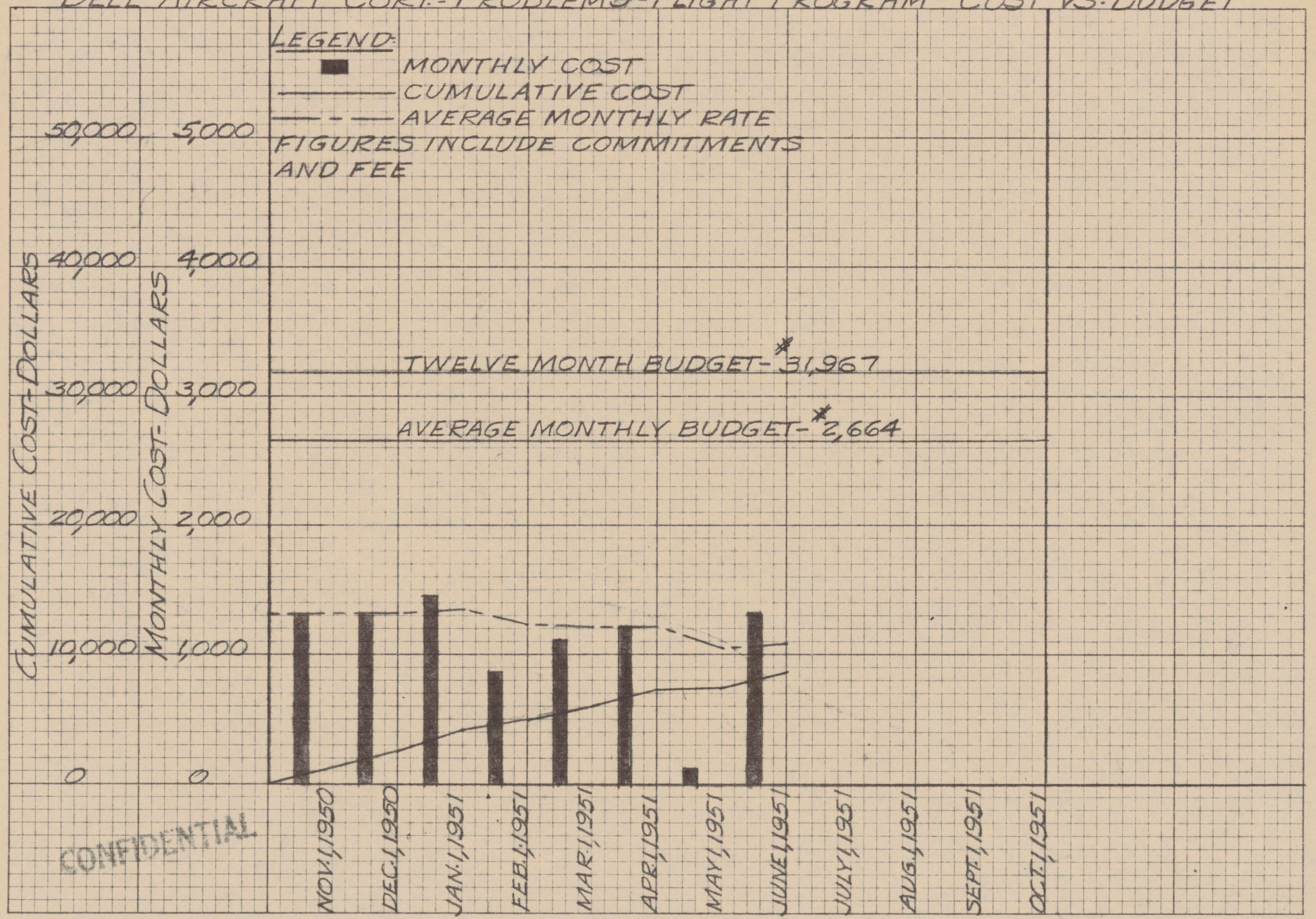


CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

PROJECT METEOR

BELL AIRCRAFT CORP.- PROBLEM 5 - FLIGHT PROGRAM - COST VS. BUDGET

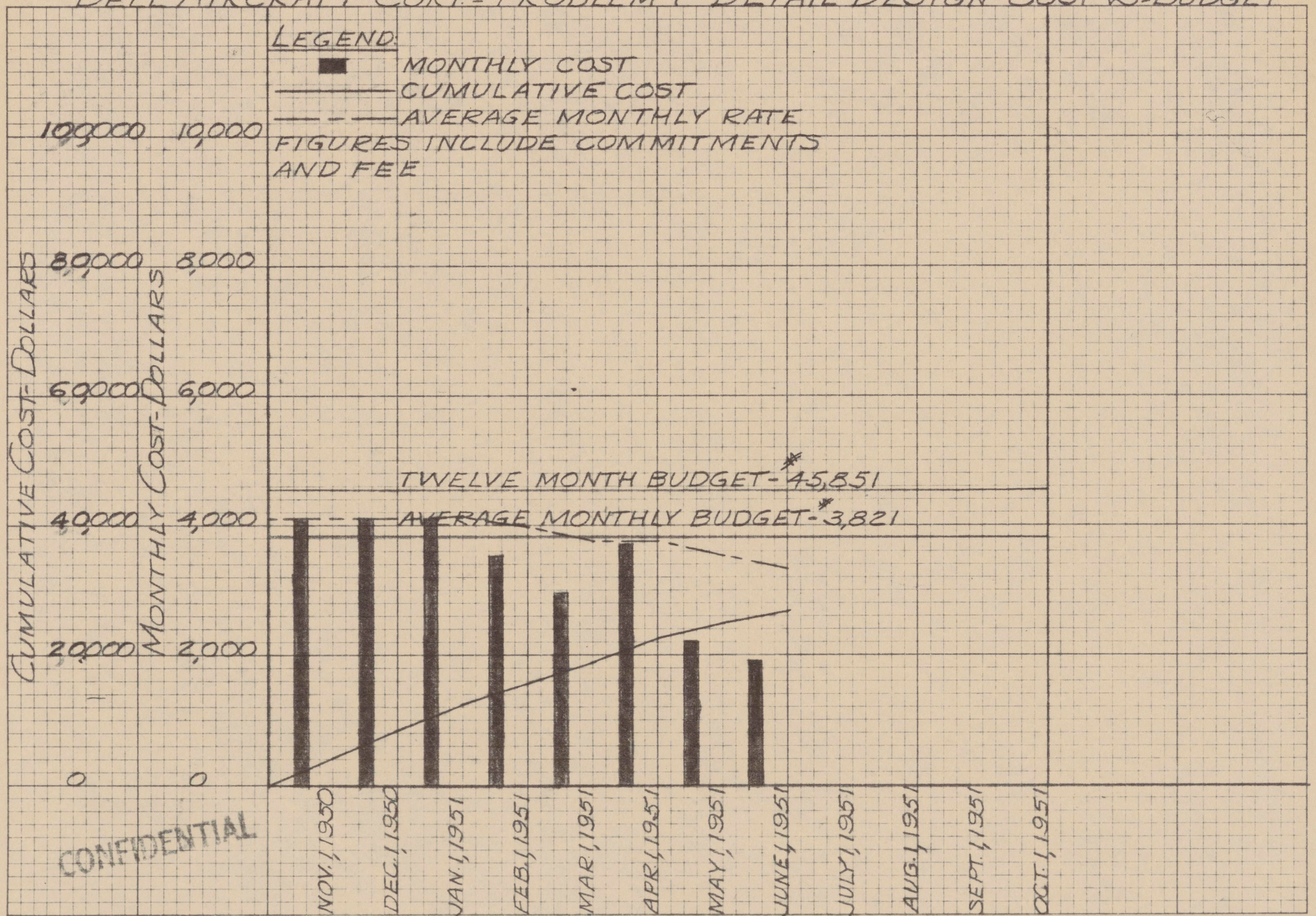


CONFIDENTIAL

NO. 31.190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

PROJECT METEOR

BELL AIRCRAFT CORP.- PROBLEM 7- DETAIL DESIGN- COST VS- BUDGET

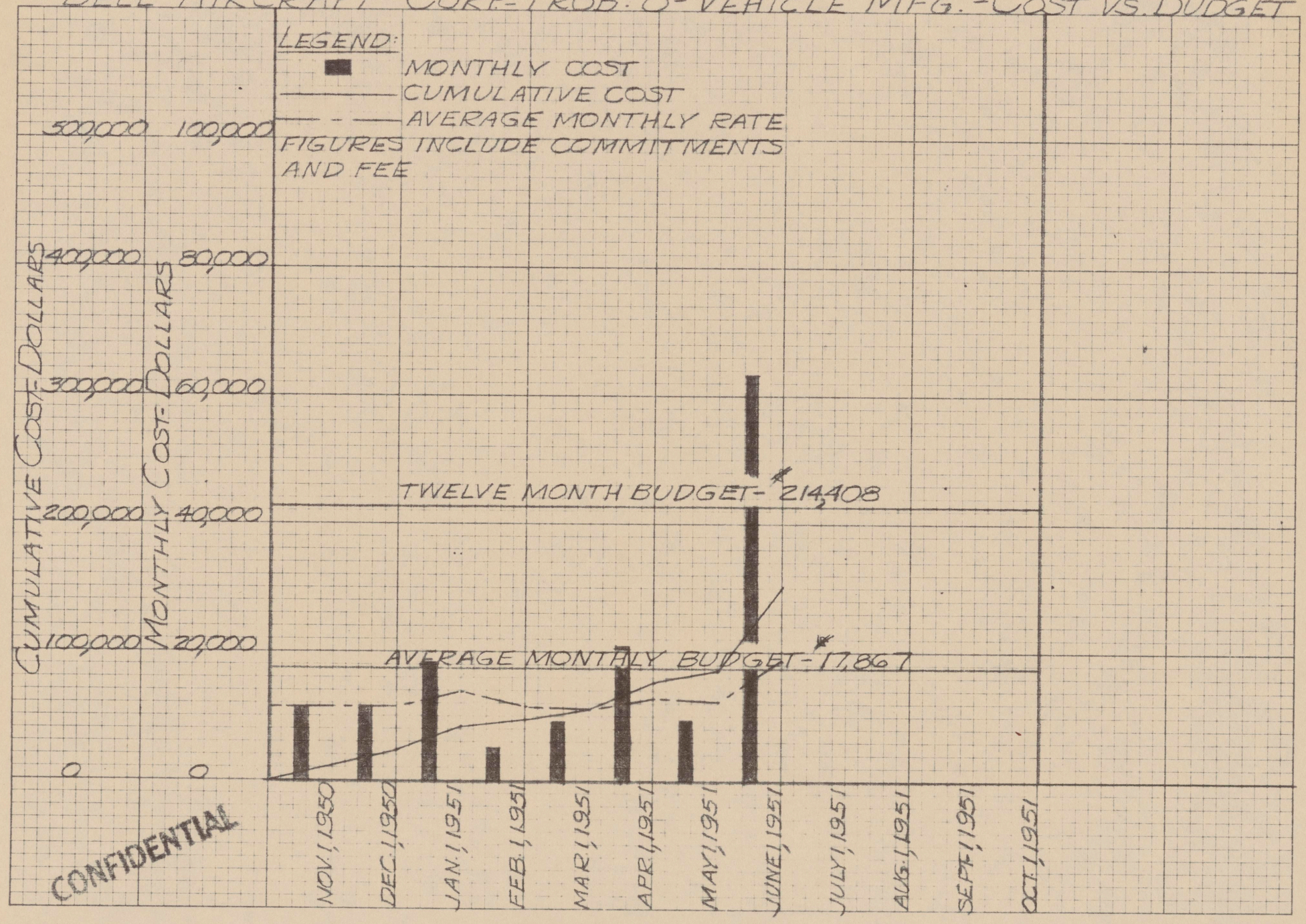


CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS.
CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

PROJECT METEOR

BELL AIRCRAFT CORP - PROB. 8 - VEHICLE MFG. - COST VS. BUDGET

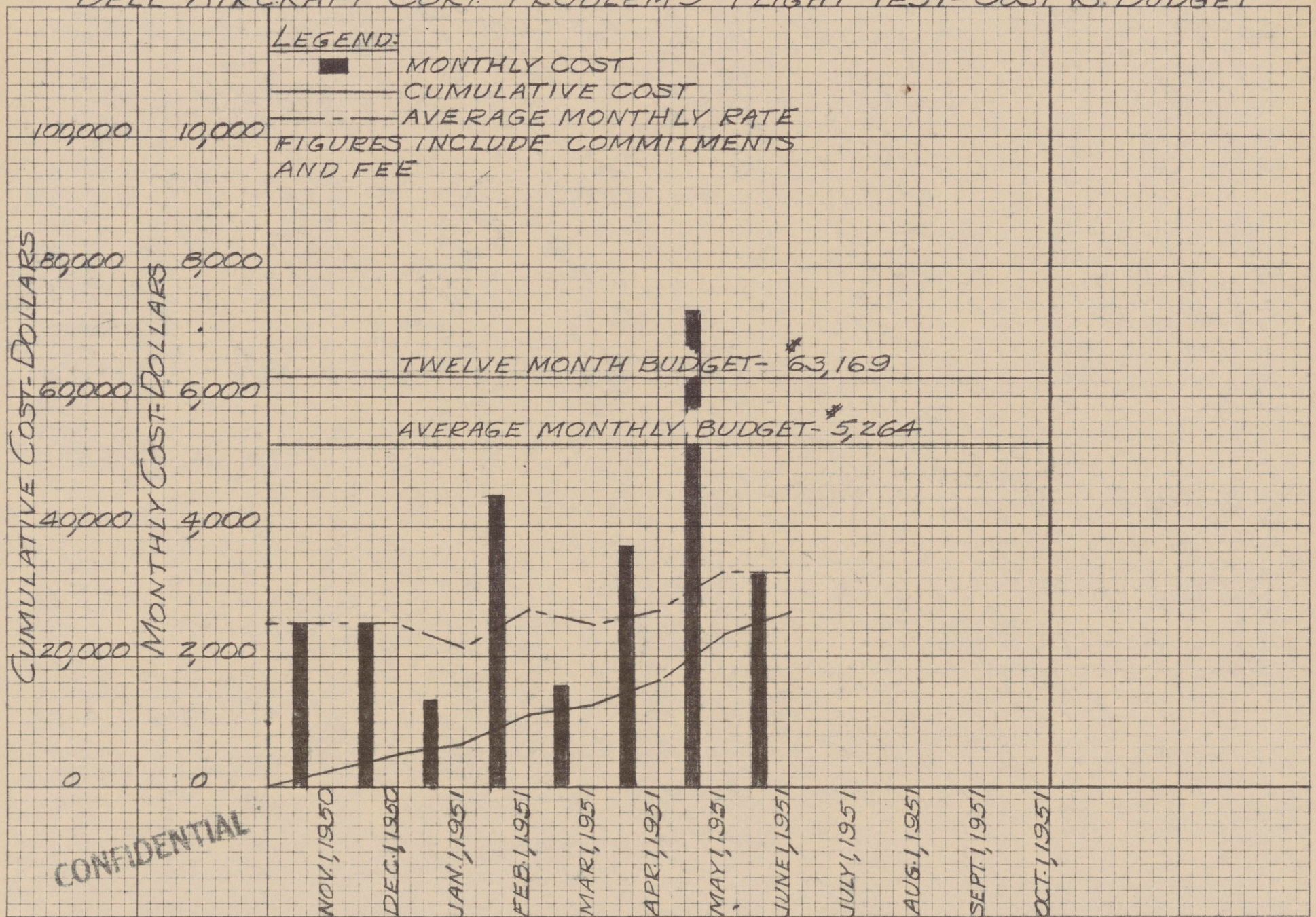


CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

PROJECT METEOR

BELL AIRCRAFT CORP.- PROBLEM 9- FLIGHT TEST- COST VS. BUDGET

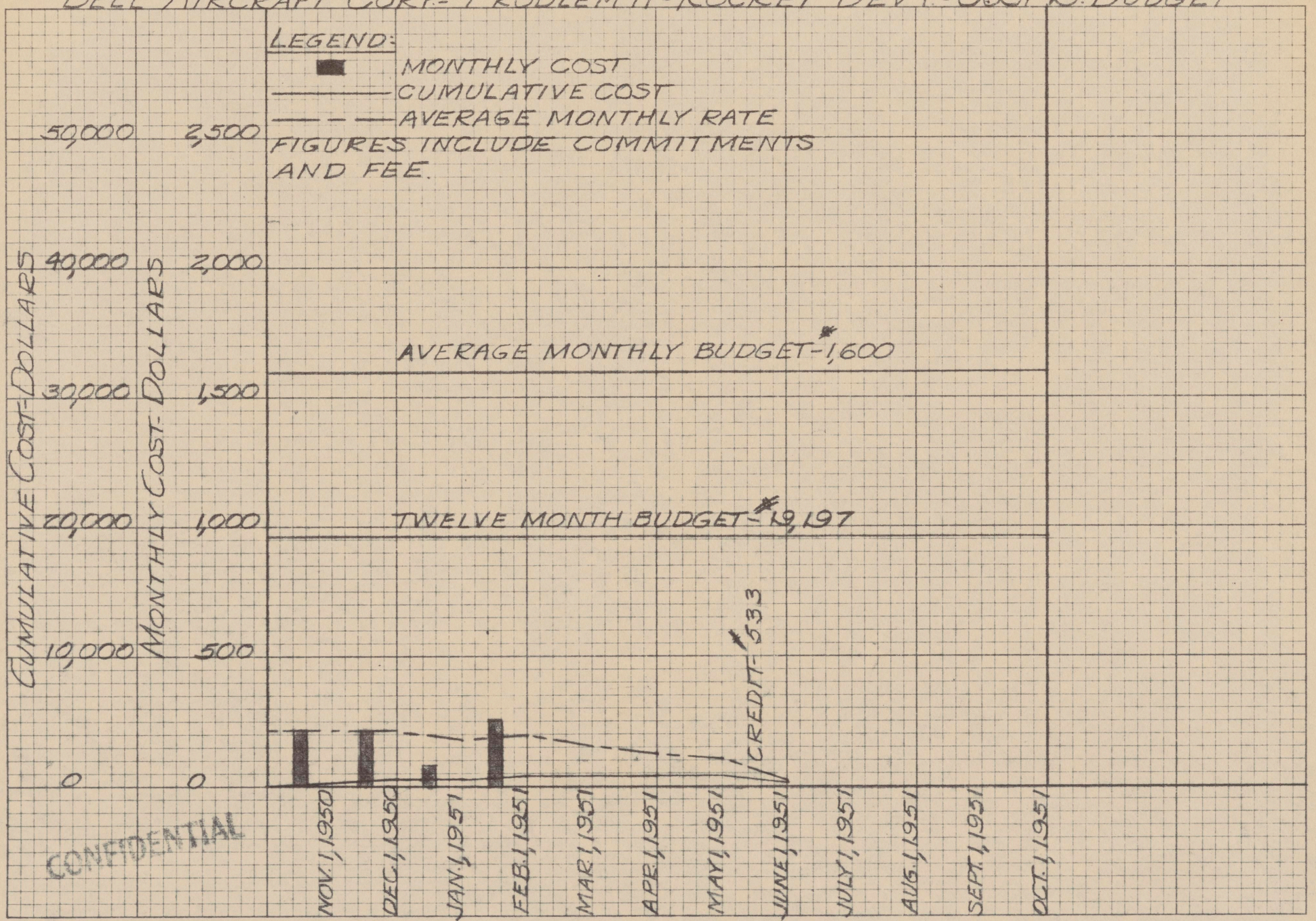


CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

PROJECT METEOR

BELL AIRCRAFT CORP.- PROBLEM II- ROCKET DEV'T.- COST VS. BUDGET



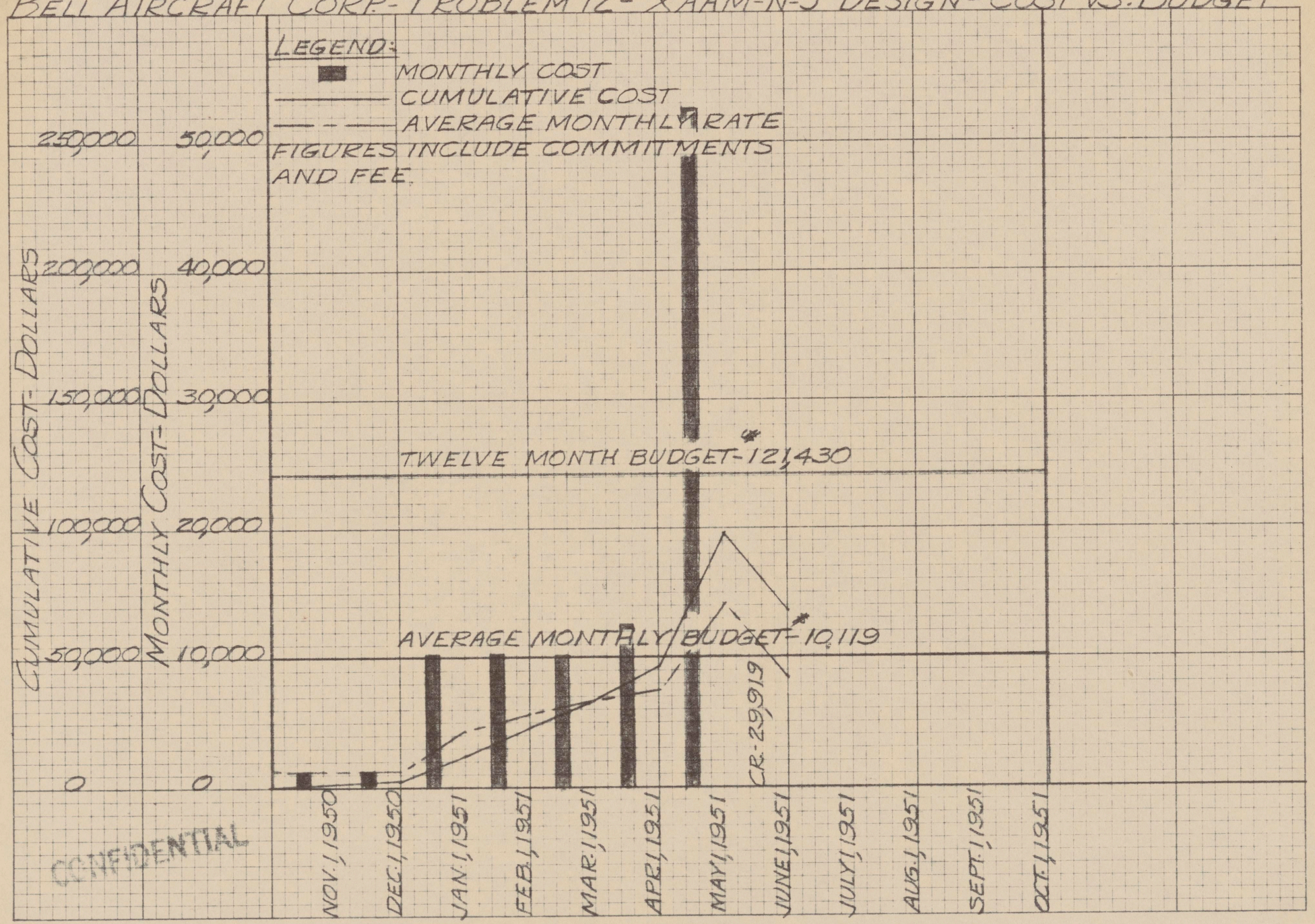
CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

29

PROJECT METEOR

BELL AIRCRAFT CORP.- PROBLEM 12- XAAM-N-5 DESIGN- COST VS. BUDGET



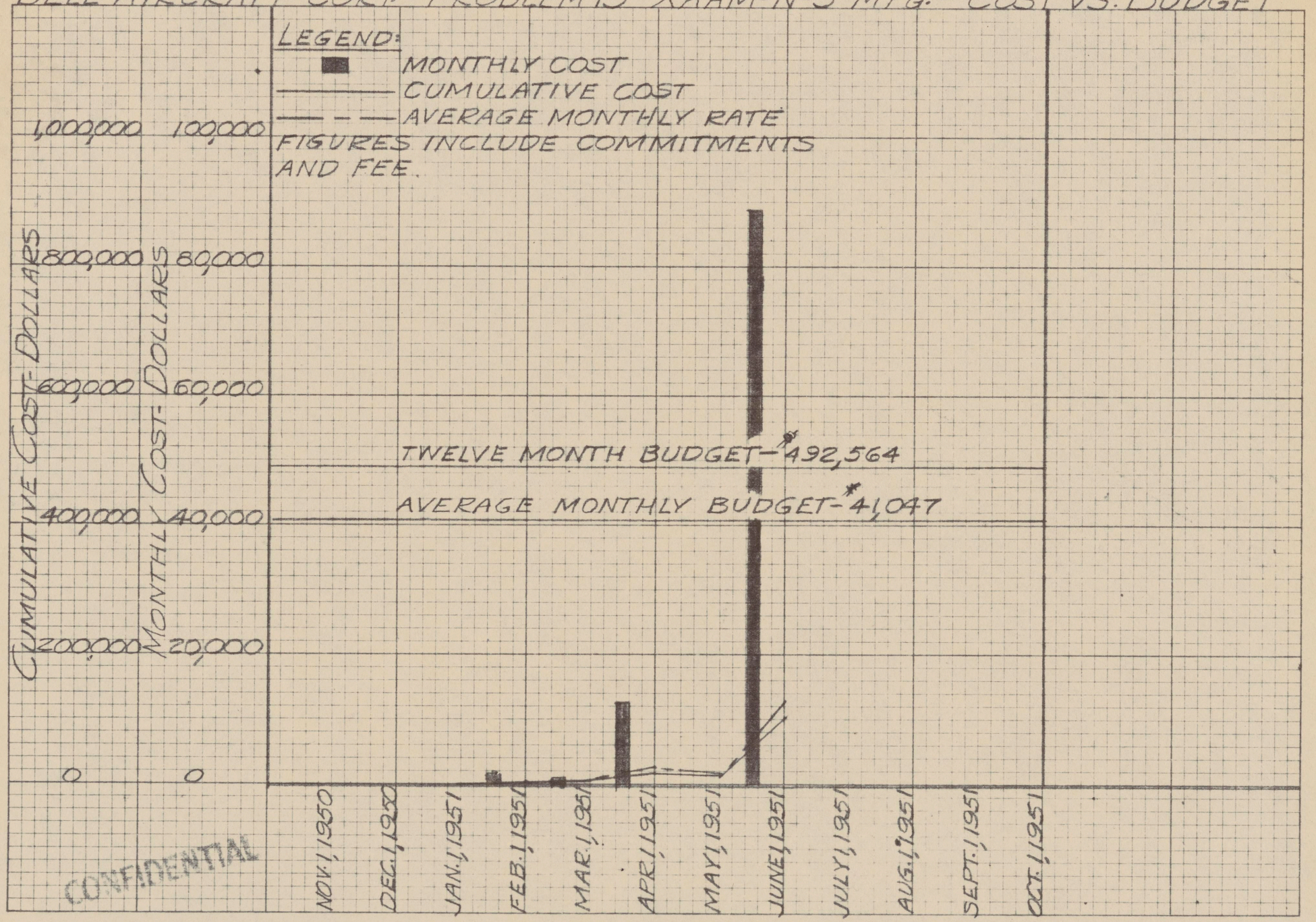
CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 × 100 DIVISIONS

CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

PROJECT METEOR

BELL AIRCRAFT CORP.- PROBLEM 13- XAAM-N-5 MFG.- COST VS. BUDGET



CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

1

PROJECT METEOR #2

PROJECT TOTAL — COST VS. BUDGET

Dr J P Killian Jr

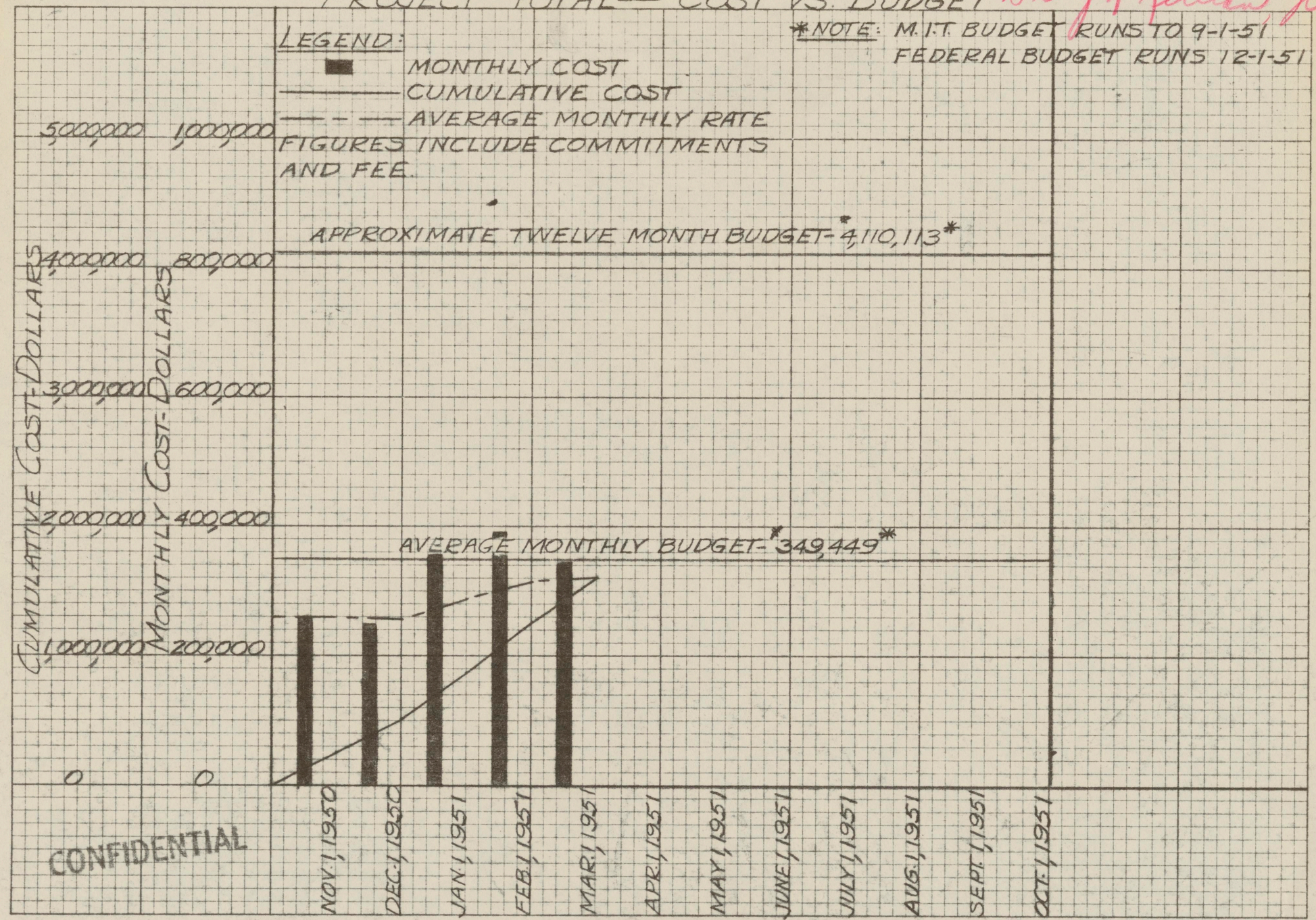
*NOTE: M.I.T. BUDGET RUNS TO 9-1-51
FEDERAL BUDGET RUNS 12-1-51

LEGEND:
- ■ MONTHLY COST
- ——— CUMULATIVE COST
- — - — AVERAGE MONTHLY RATE

FIGURES INCLUDE COMMITMENTS AND FEE.

APPROXIMATE TWELVE MONTH BUDGET-*4,110,113*

AVERAGE MONTHLY BUDGET-*349,449*



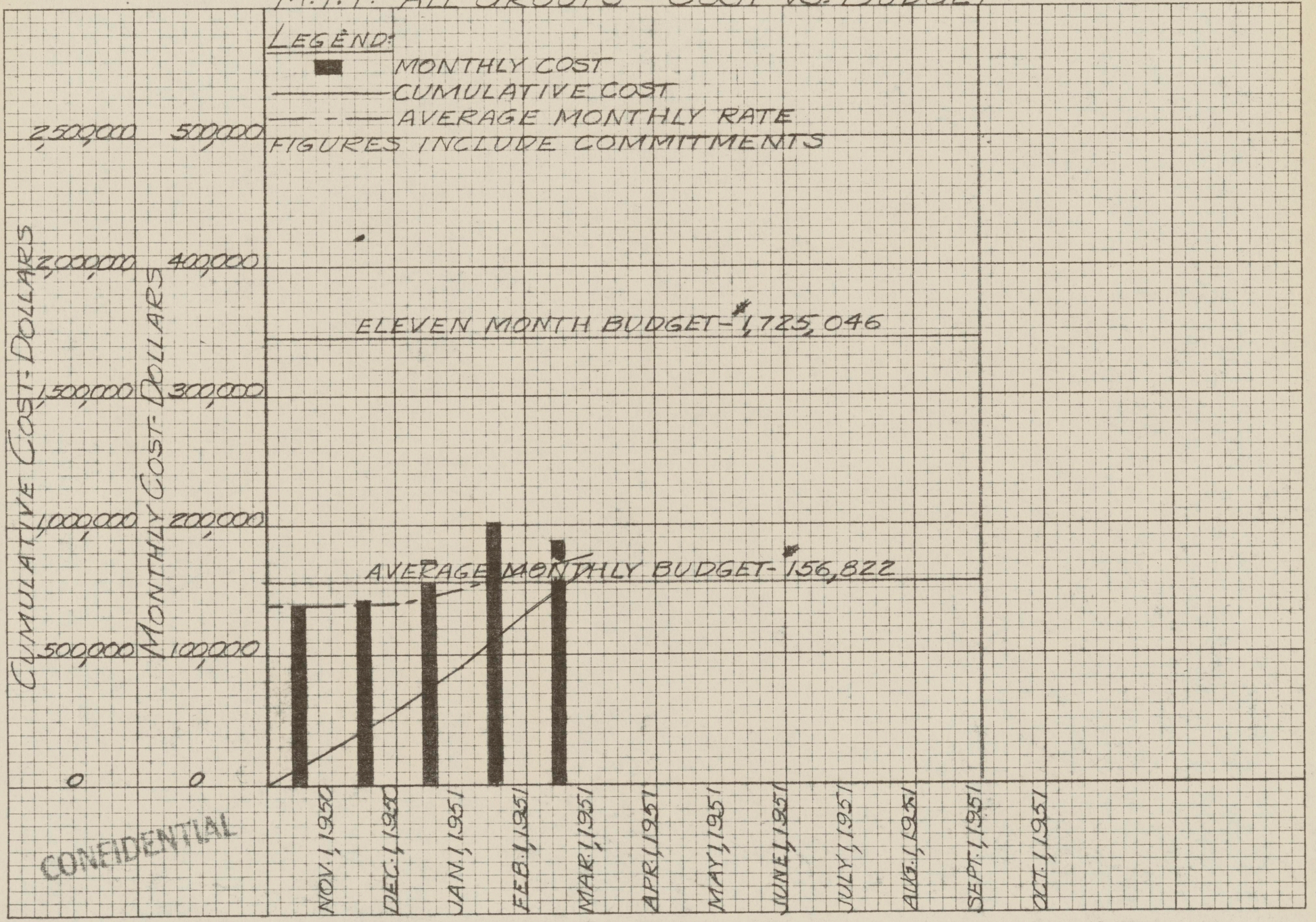
CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

2

PROJECT METEOR

M.I.T. - ALL GROUPS - COST VS. BUDGET



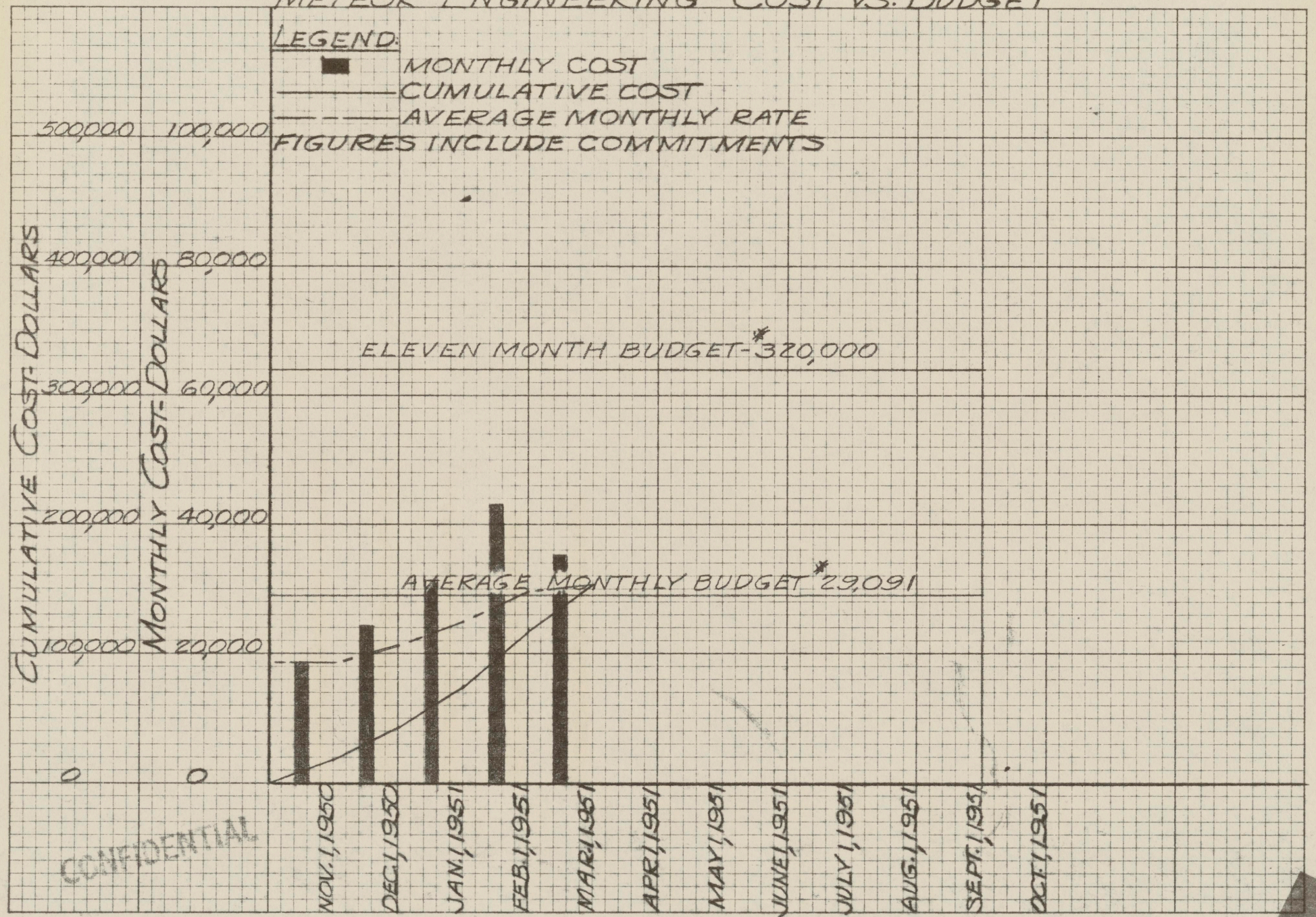
CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

13

PROJECT METEOR

METEOR ENGINEERING - COST VS. BUDGET

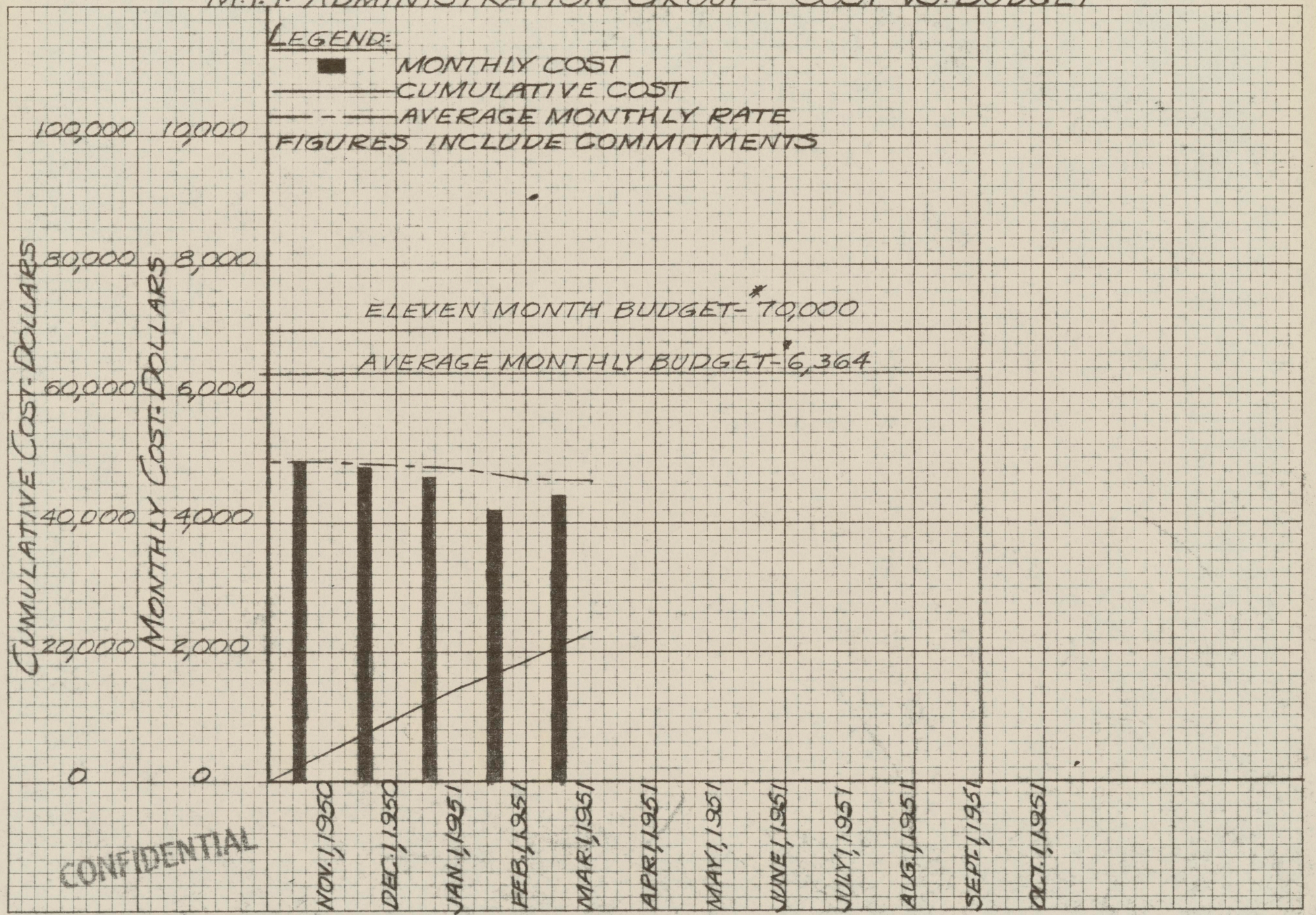


CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

PROJECT METEOR

M.I.T. ADMINISTRATION GROUP- COST VS. BUDGET



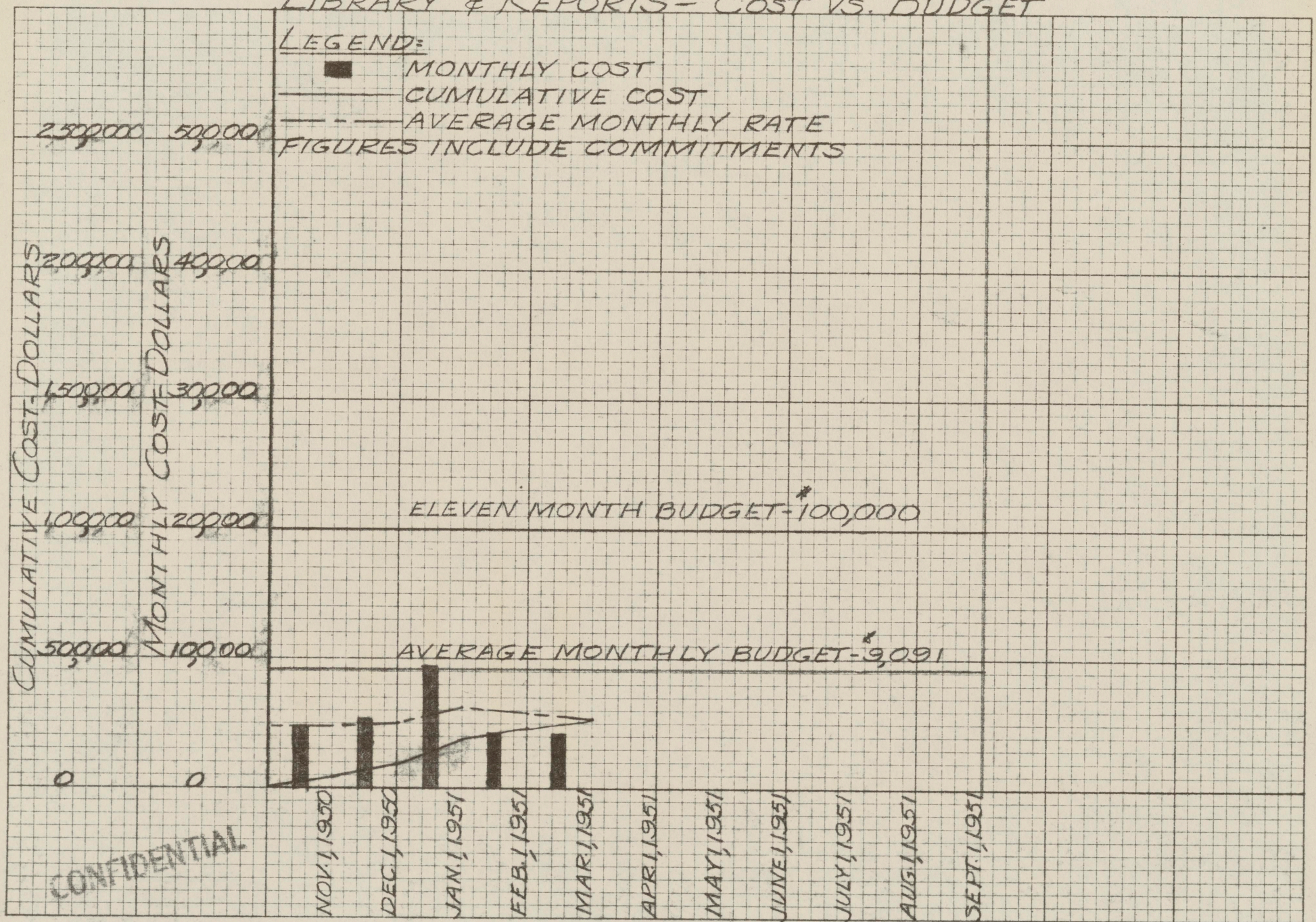
CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

5

PROJECT METEOR

LIBRARY & REPORTS – COST VS. BUDGET

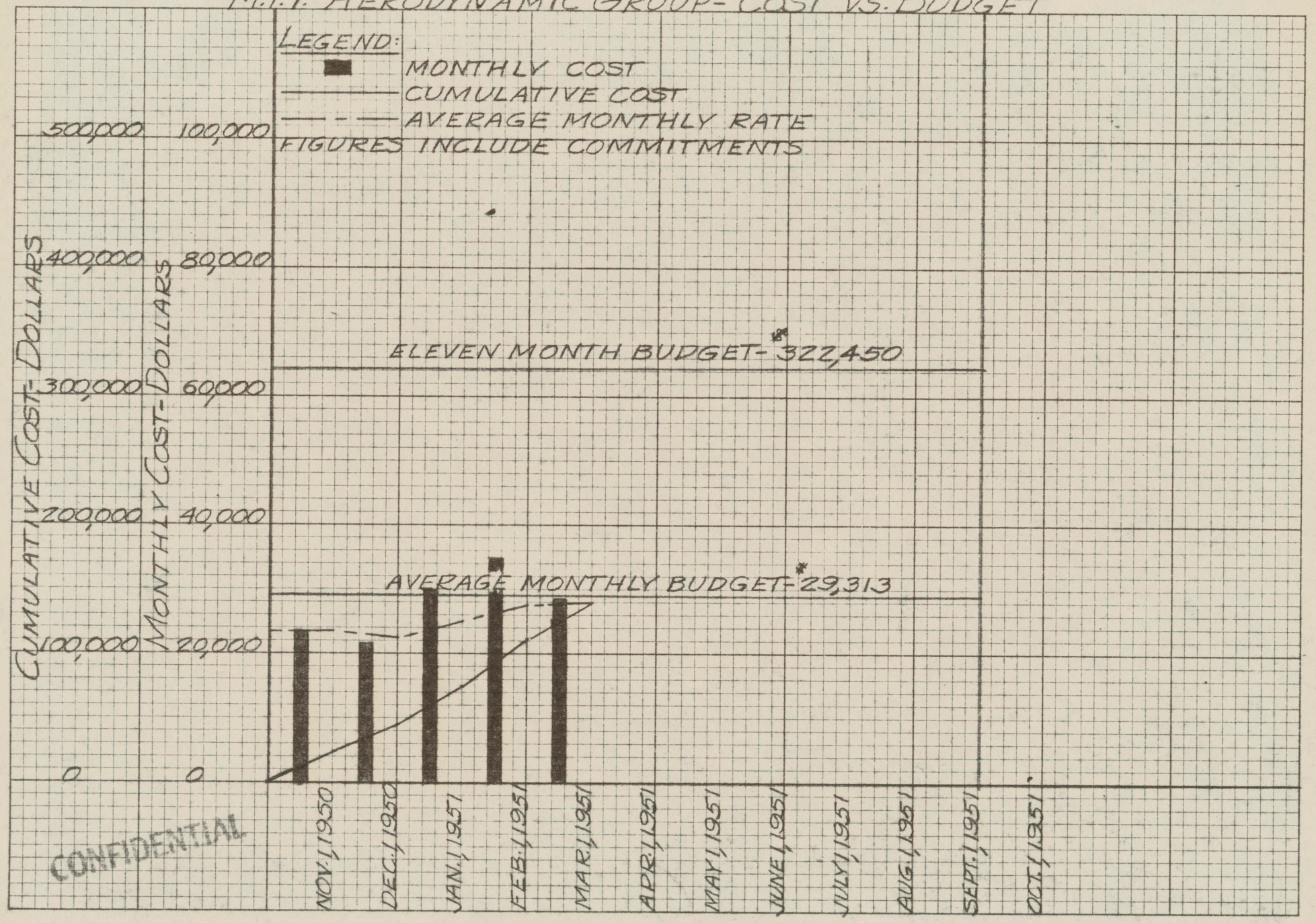


CONFIDENTIAL

NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 20 X 100 DIVISIONS.
CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

PROJECT METEOR

M.I.T. AERODYNAMIC GROUP - COST VS. BUDGET



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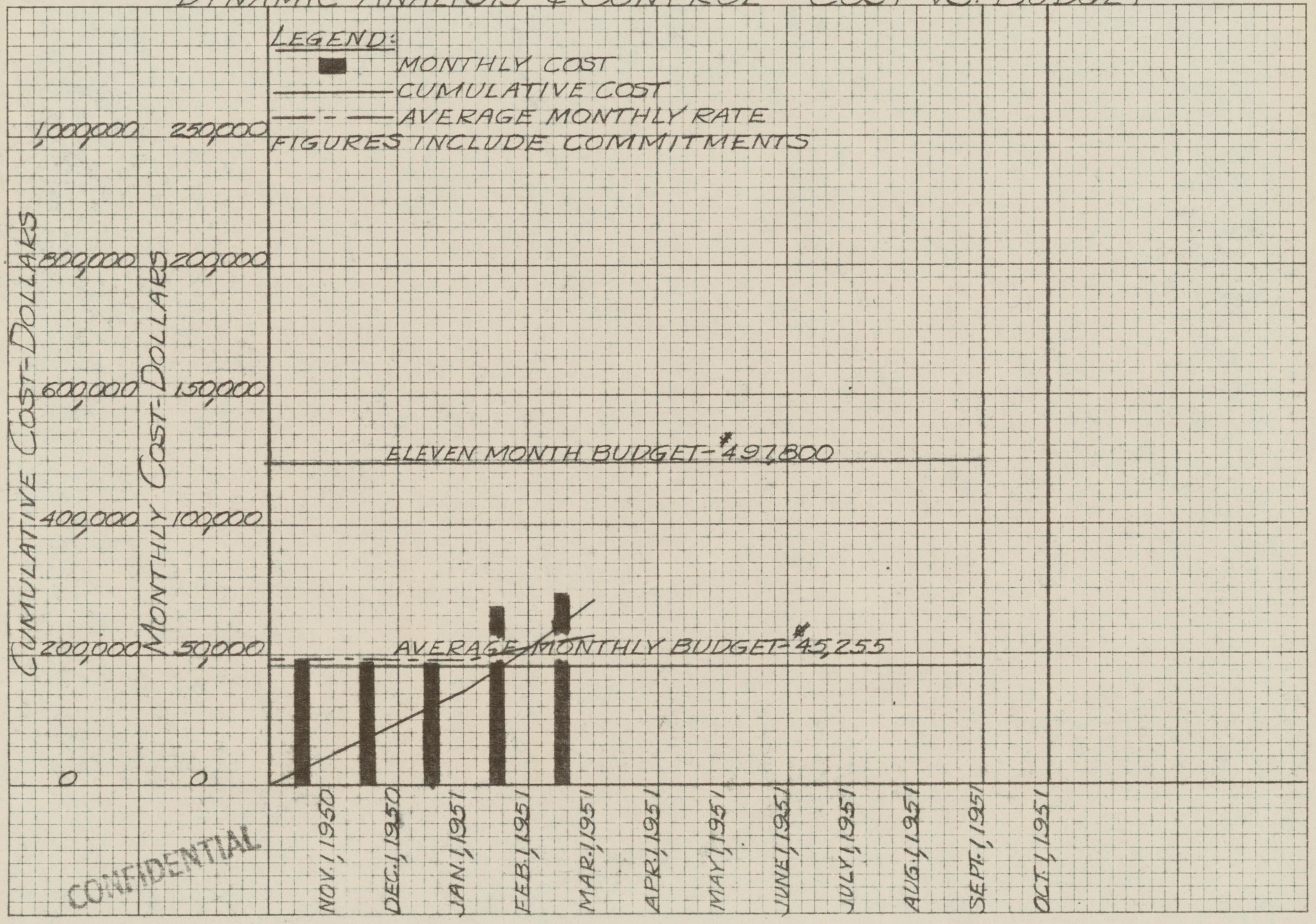
NO. 31,190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

7

PROJECT METEOR

DYNAMIC ANALYSIS & CONTROL - COST VS. BUDGET



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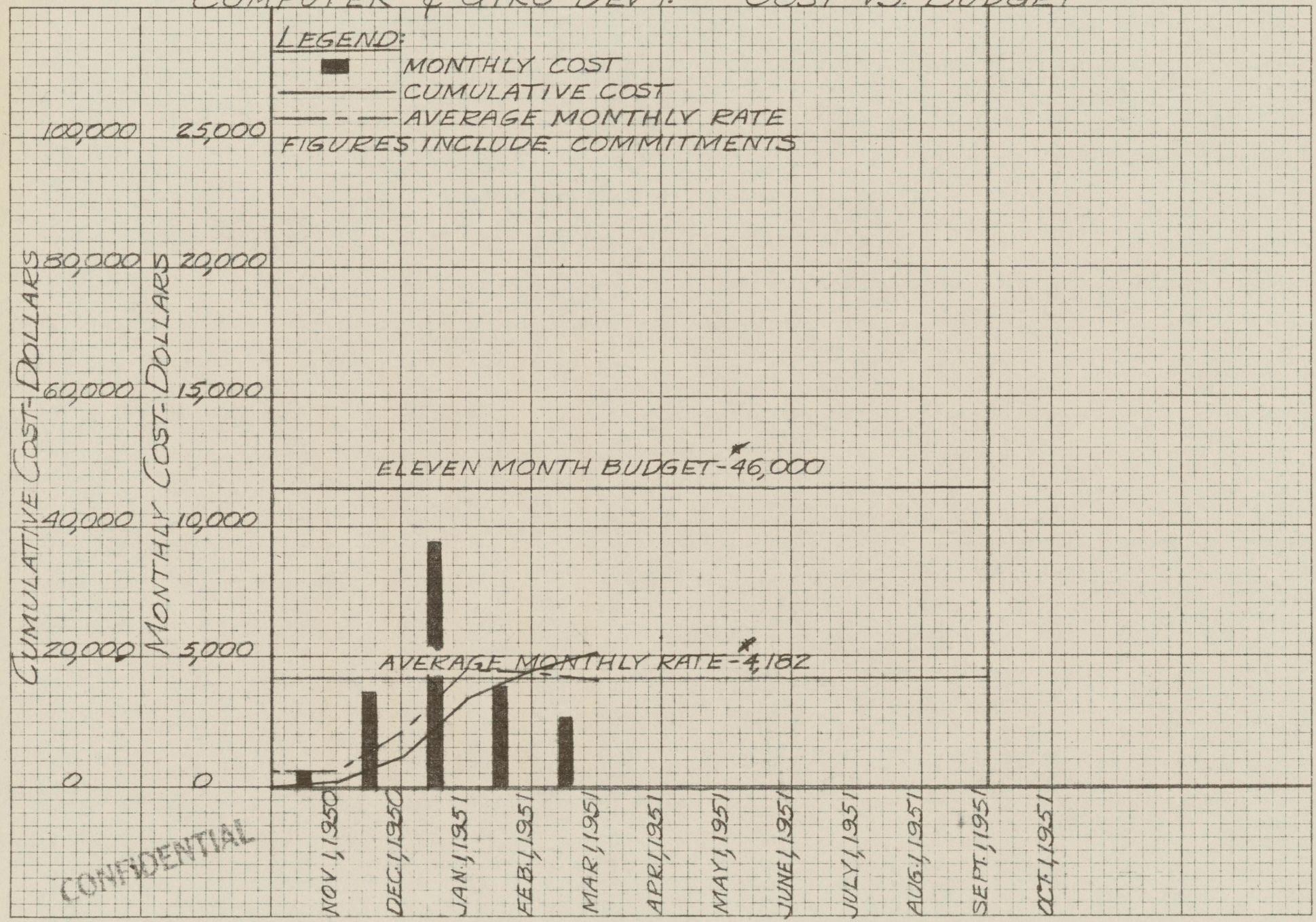
8

PROJECT METEOR

COMPUTER & GYRO DEV'T. — COST VS. BUDGET



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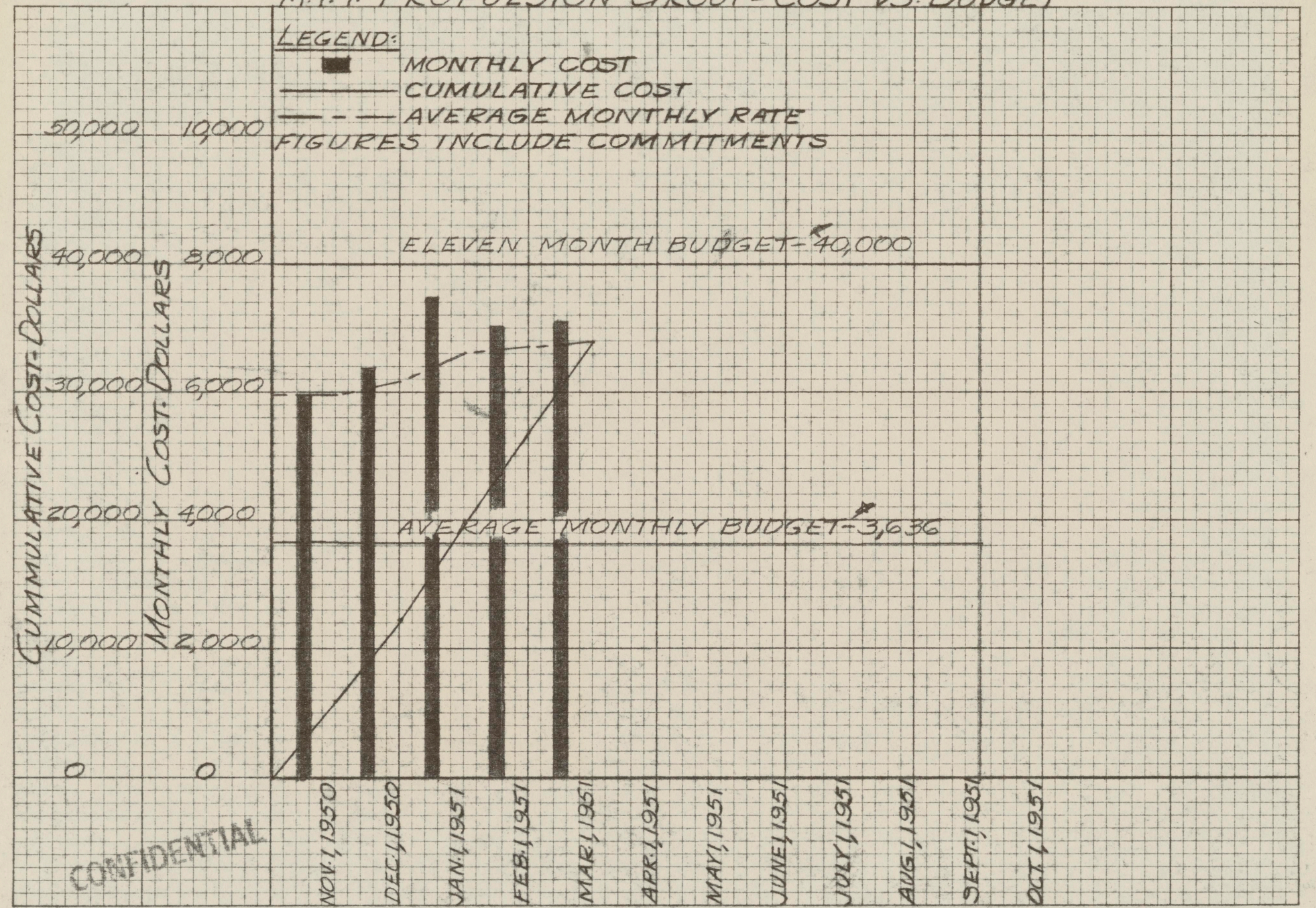
9

PROJECT METEOR

M.I.T. PROPULSION GROUP - COST VS. BUDGET



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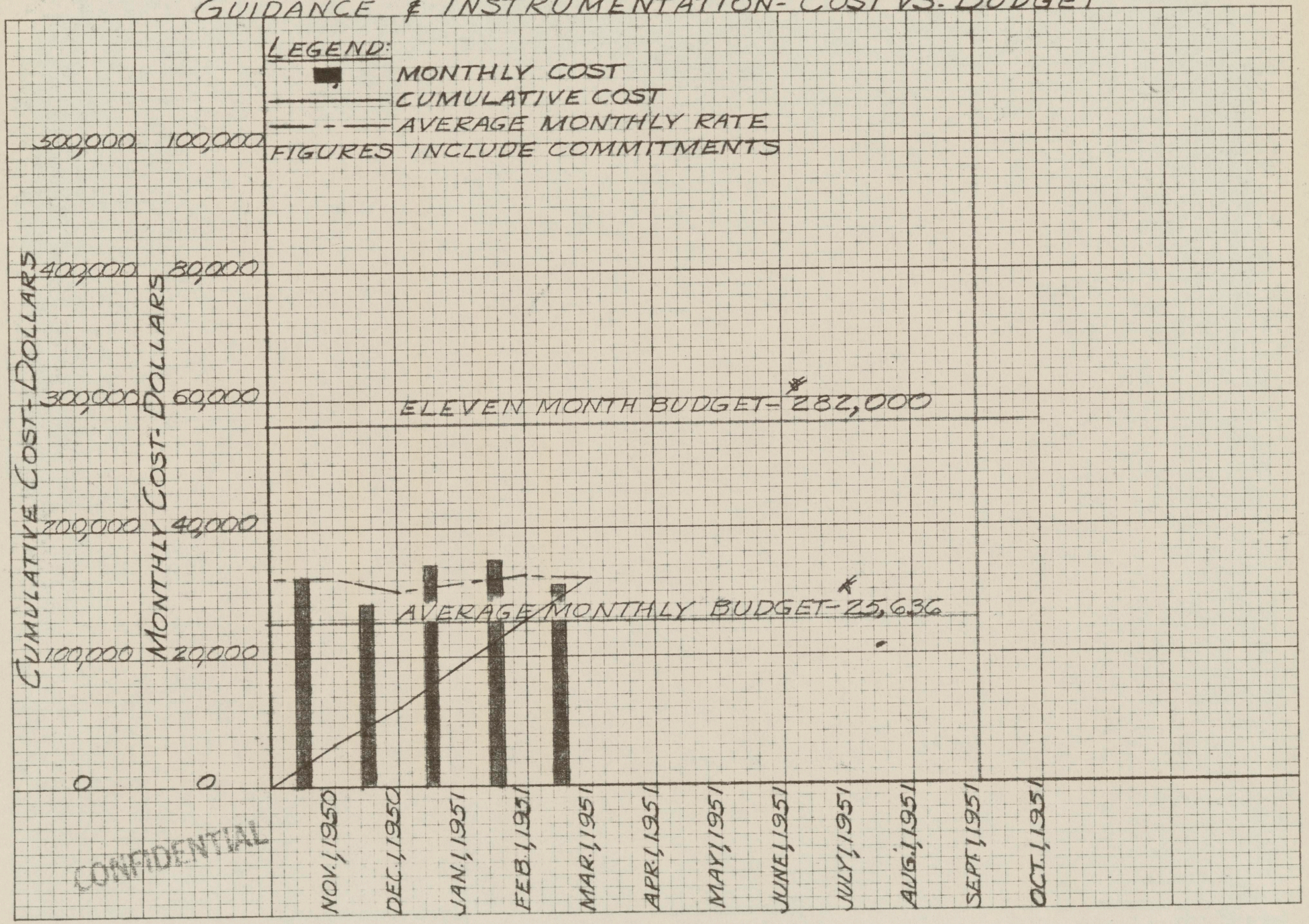
PROJECT METEOR

GUIDANCE & INSTRUMENTATION- COST VS. BUDGET



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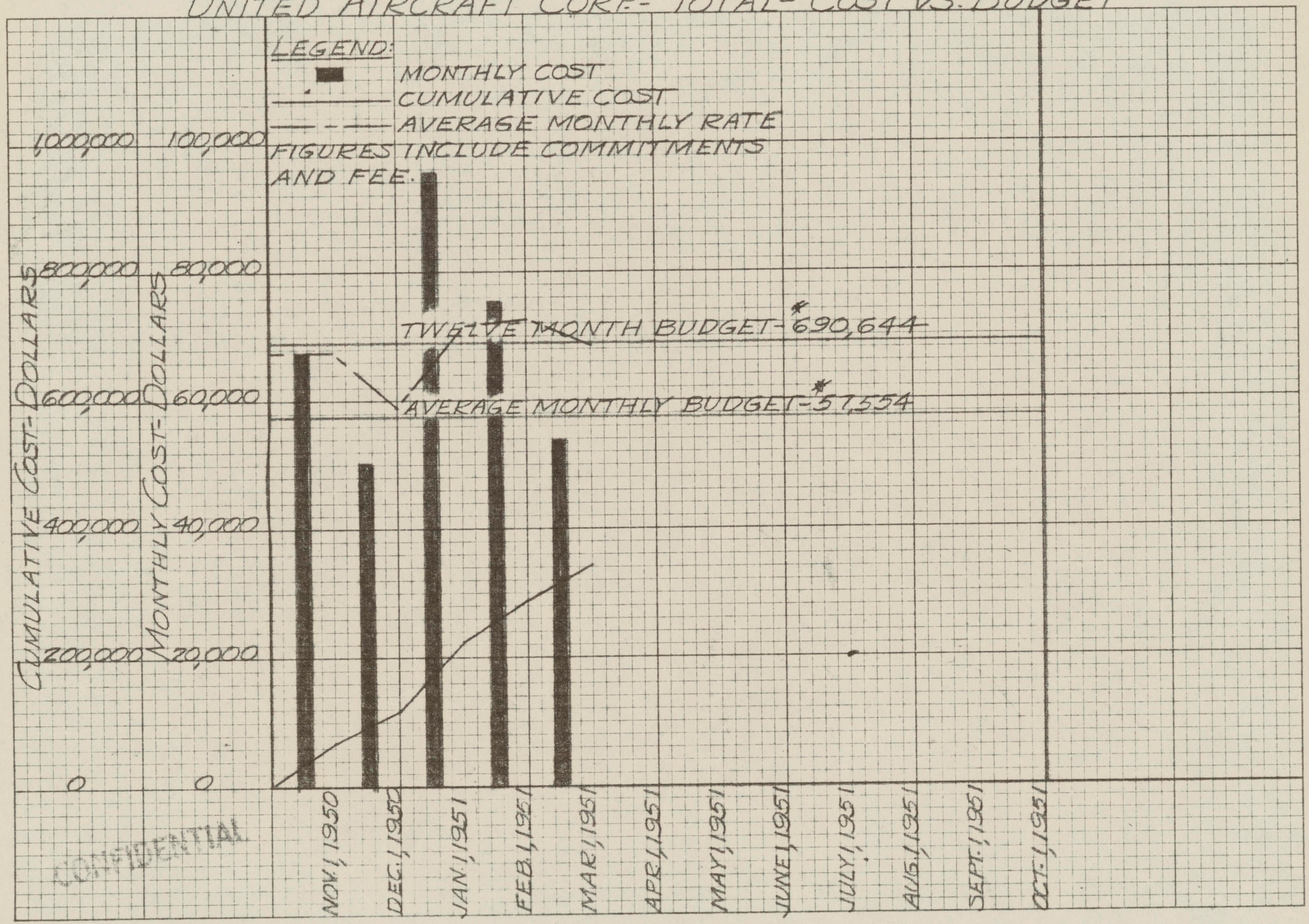
11

PROJECT METEOR

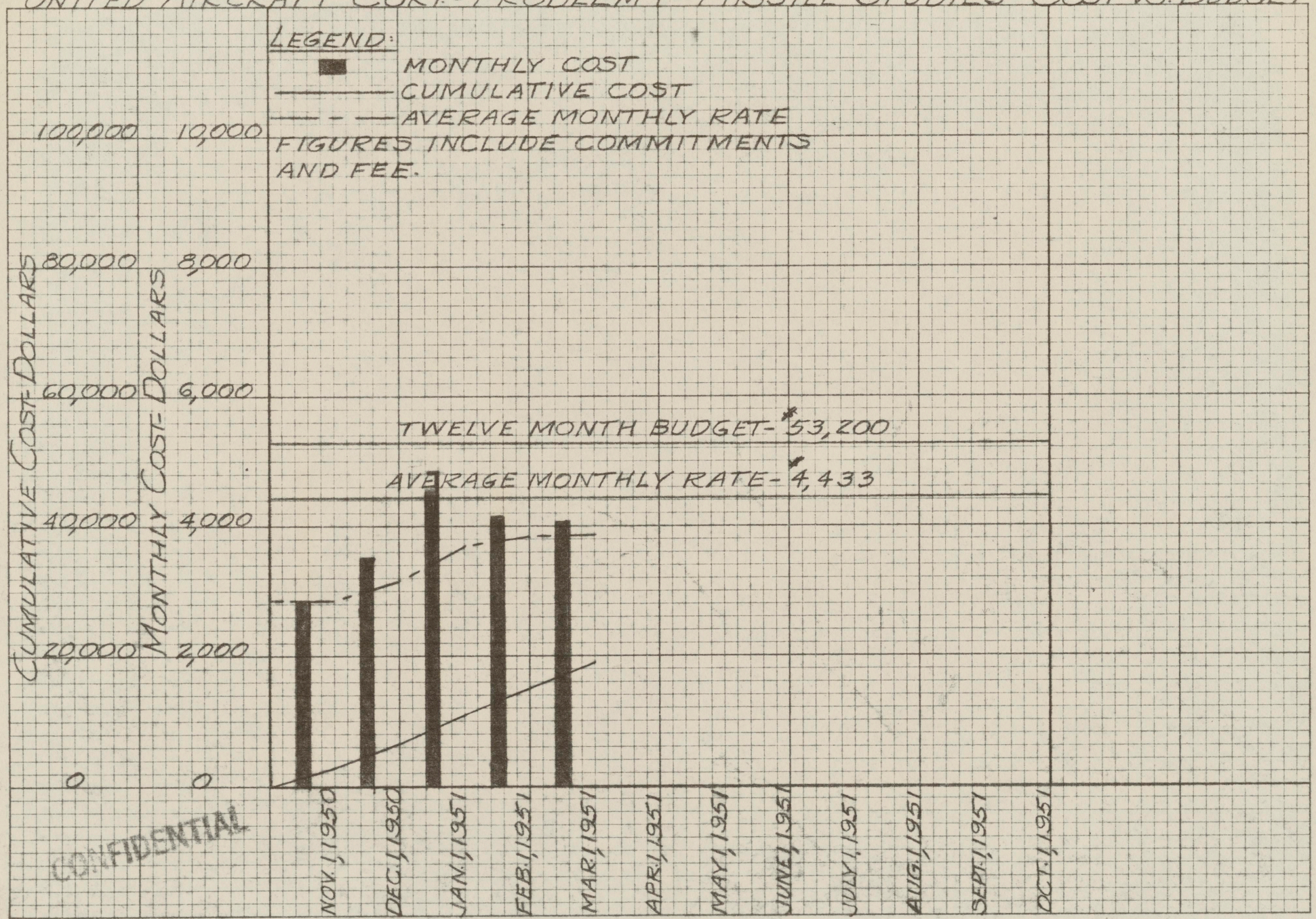
UNITED AIRCRAFT CORP.- TOTAL- COST VS. BUDGET



NO. 31.190. 10 DIVISIONS PER INCH BOTH WAYS. 70 X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

PROJECT METEOR

UNITED AIRCRAFT CORP.- PROBLEM 7- MISSILE STUDIES- COST VS. BUDGET



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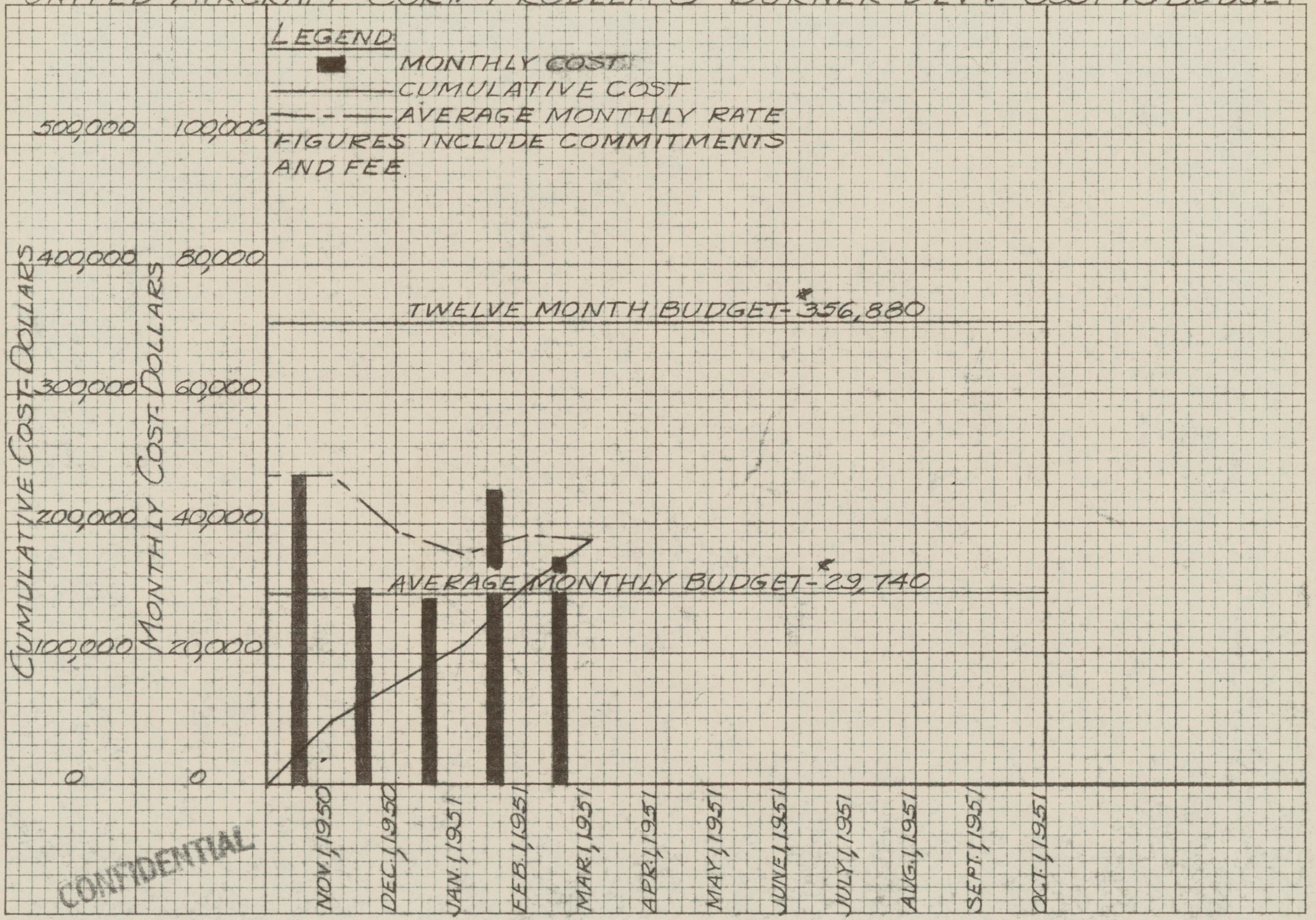
13

PROJECT METEOR

UNITED AIRCRAFT CORP.- PROBLEM 8- BURNER DEV'T.- COST VS BUDGET



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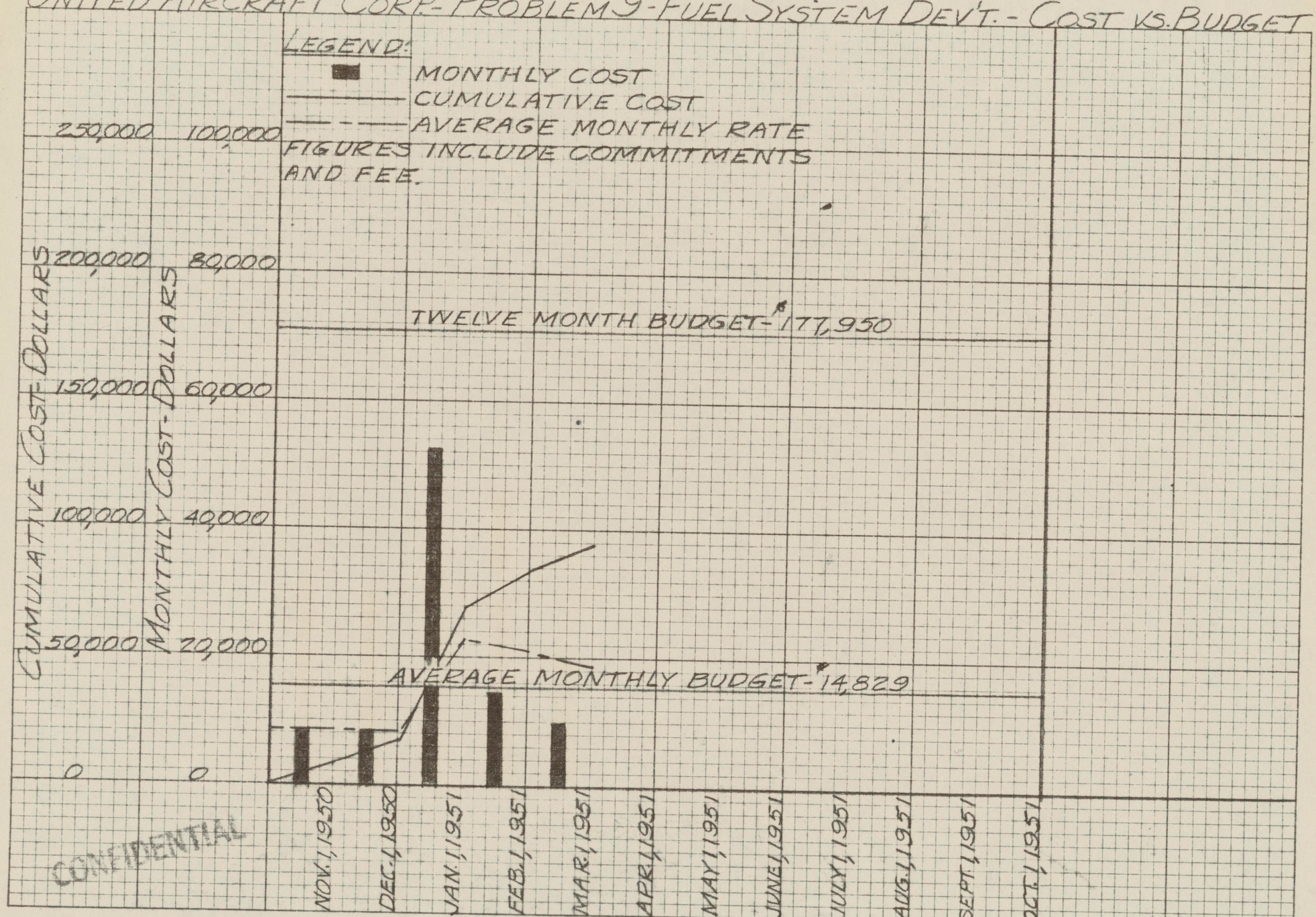
PROJECT METEOR

UNITED AIRCRAFT CORP. - PROBLEM 9 - FUEL SYSTEM DEV'T. - COST VS. BUDGET



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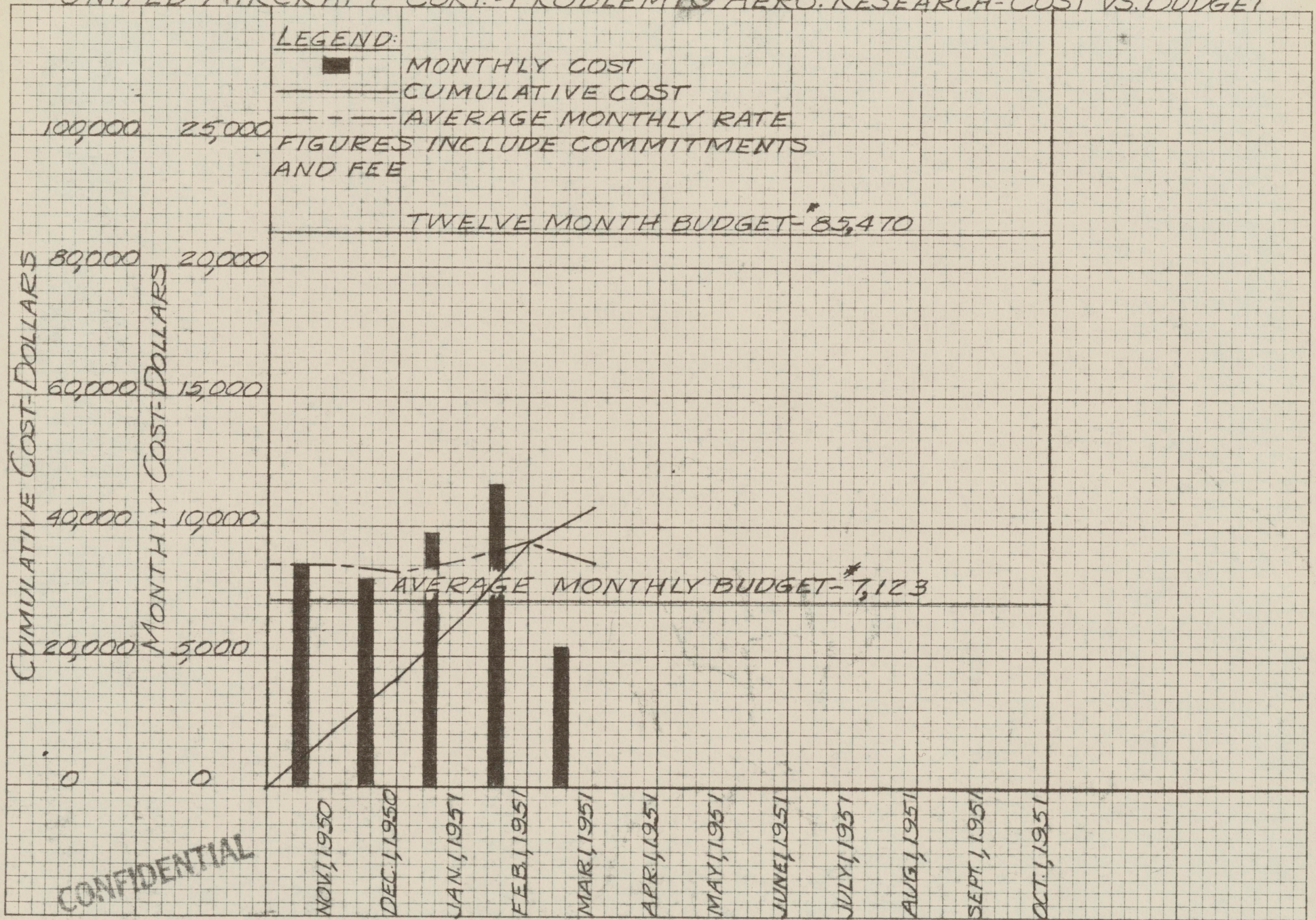
15

PROJECT METEOR

UNITED AIRCRAFT CORP.- PROBLEM 10-AERO. RESEARCH- COST VS. BUDGET



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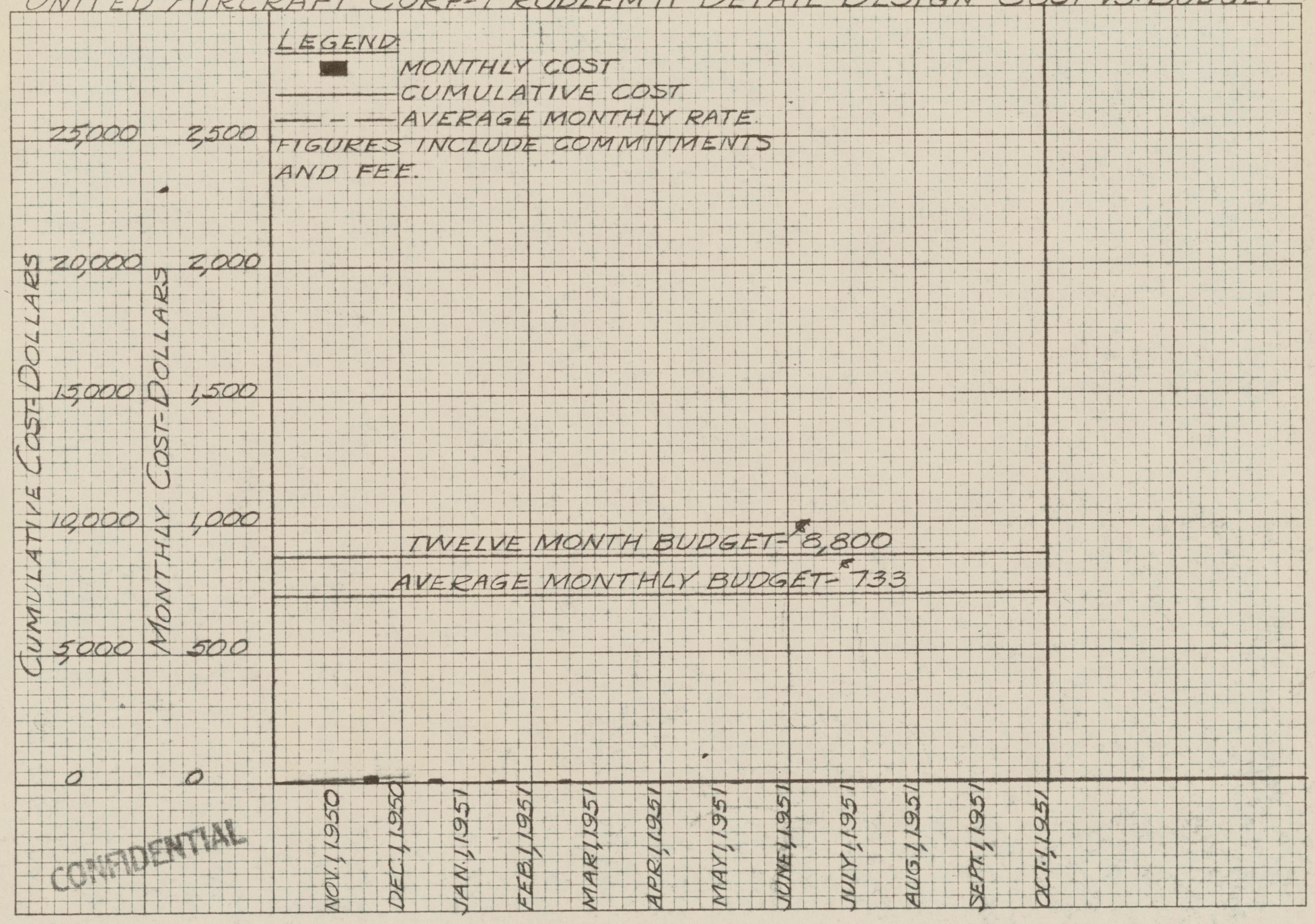
PROJECT METEOR

UNITED AIRCRAFT CORP - PROBLEM II - DETAIL DESIGN - COST VS. BUDGET



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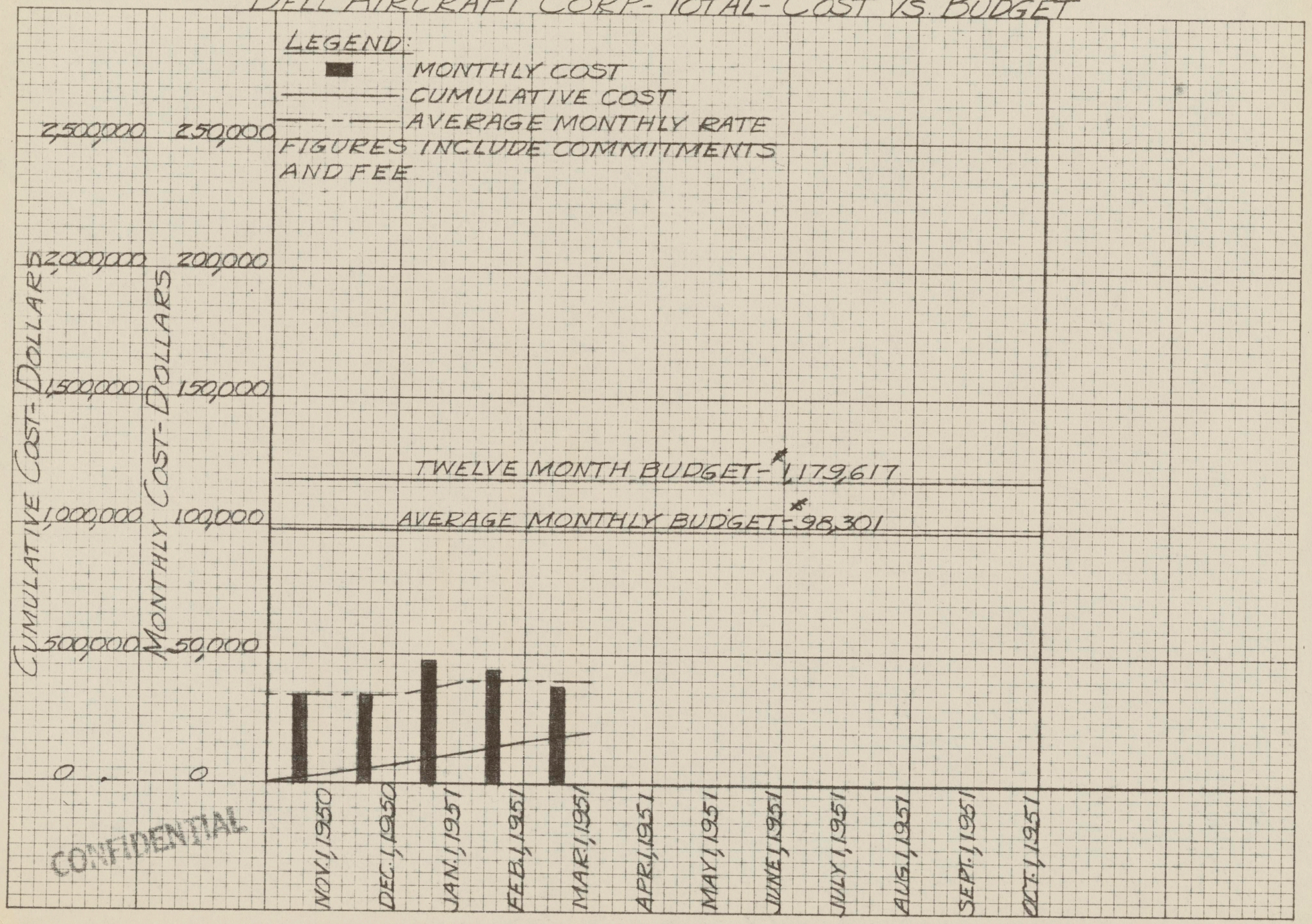
CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.

17

PROJECT METEOR

BELL AIRCRAFT CORP - TOTAL - COST VS. BUDGET



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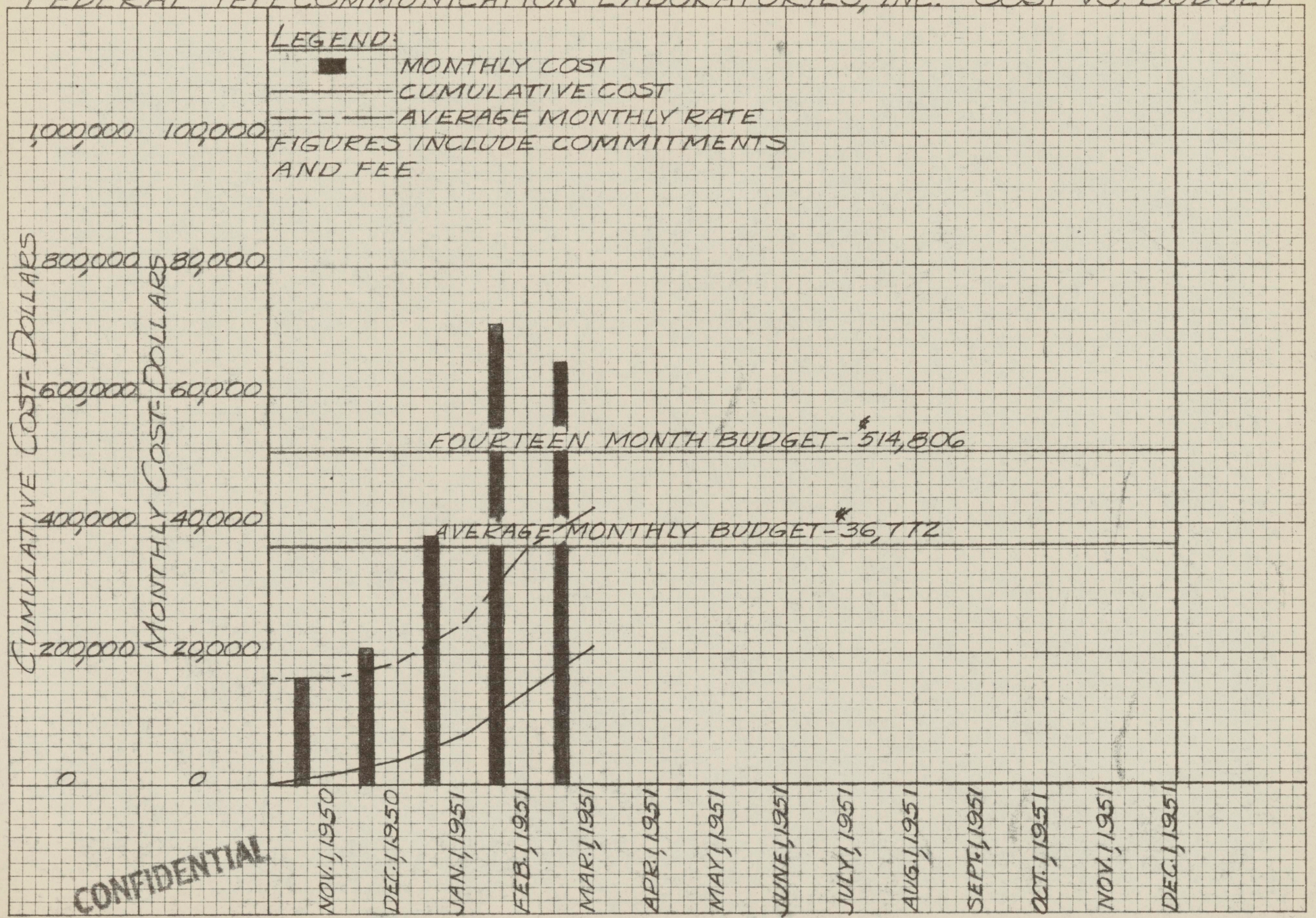
PROJECT METEOR

FEDERAL TELECOMMUNICATION LABORATORIES, INC. - COST VS. BUDGET



CONFIDENTIAL

	1947	1948	1949	1950
ROCKET PROPULSION				
1. ROCKET RESEARCH & DEV'T.	$300,000	$400,000	$250,000	$150,000
2. ROCKET VEHICLE DESIGN STUDY	$60,000			
RAMJET PROPULSION				
1. RAMJET RESEARCH & DEV'T.	$130,000	$220,000	$250,000	$250,000
2. RAMJET VEHICLE DESIGN STUDY	$80,000			
AERODYNAMICS				
1. AERO. RESEARCH & DEV'T.	$130,000	$220,000	$100,000	$100,000
2. AERO. VEHICLE DESIGN STUDY	$50,000			
CONTROL & GUIDANCE				
1. CONTROL & GUIDANCE DEV'T.	$250,000	$500,000	$500,000	$500,000
VEHICLES & MISSILES				
1. RAMJET-POWERED VEHICLE				
a. DESIGN STUDIES		$60,000	$40,000	$40,000
b. DESIGN, FAB. & TEST			$500,000	$320,000
2 ROCKET-POWERED VEHICLE				
a. DESIGN STUDIES	$60,000	$40,000	$40,000	$40,000
b. DESIGN, FAB. & TEST		$550,000	$150,000	$350,000
3. MISSILE DESIGN STUDIES				$50,000
MISCELLANEOUS				
1. INSTRUMENTATION		$250,000		
	EXPEND. $1,060,000	EXPEND. $2,240,000	EXPEND. $1,830,000	EXPEND. $1,800,000

JUL. 1, 1947 | JUL. 1, 1948 | JUL. 1, 1949 | JUL. 1, 1950

PROJECT METEOR
ASSOCIATED CONTRACTORS PROGRAM
MODIFIED PLAN
AS OF JAN. 29, 1947

CHART "A"

1-29-47

THB

EUGENE DIETZGEN CO. MADE IN U.S.A.
NO. 340D-10 DIETZGEN GRAPH PAPER 10 X 10 PER INCH

	1947	JUL. 1, 1947 — 1948	JUL. 1, 1948 — 1949	JUL. 1, 1949 — 1950	JUL. 1, 1950
PROPULSION	$195,000	$260,000	$255,000	$255,000	
AERODYNAMICS	$195,000	$385,000	$310,000	$310,000	
CONTROL	$915,000	$970,000	$510,000	$520,000	
GUIDANCE	$455,000	$670,000	$420,000	$440,000	
ADMINISTRATIVE	$150,000	$175,000	$175,000	$175,000	
	EXPEND. $1,910,000	EXPEND. $2,460,000	EXPEND. $1,670,000	EXPEND. $1,700,000	

CHART "B"

PROJECT METEOR
M. I. T. PROGRAM
MODIFIED PLAN
AS OF JAN. 29, 1947

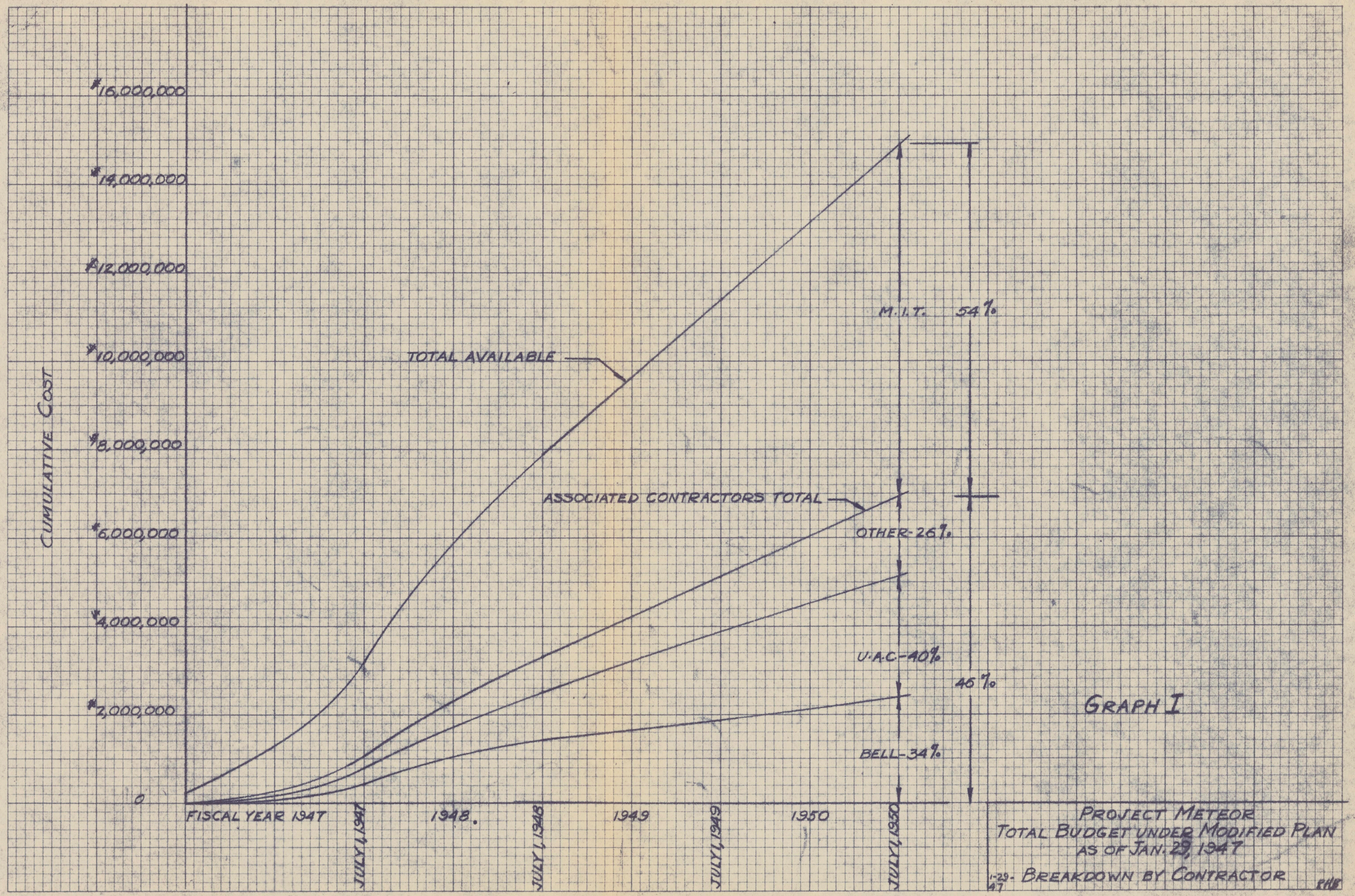
1-29-47

RMB

EUGENE DIETZGEN CO.
MADE IN U.S.A.
NO. 340D-10 DIETZGEN GRAPH PAPER
10 X 10 PER INCH

EUGENE DIETZGEN CO.
MADE IN U.S.A.

NO. 340D-10 DIETZGEN GRAPH PAPER
10 X 10 PER INCH



GRAPH I

PROJECT METEOR
TOTAL BUDGET UNDER MODIFIED PLAN
AS OF JAN. 29, 1947

1-29-47 - BREAKDOWN BY CONTRACTOR

RHB

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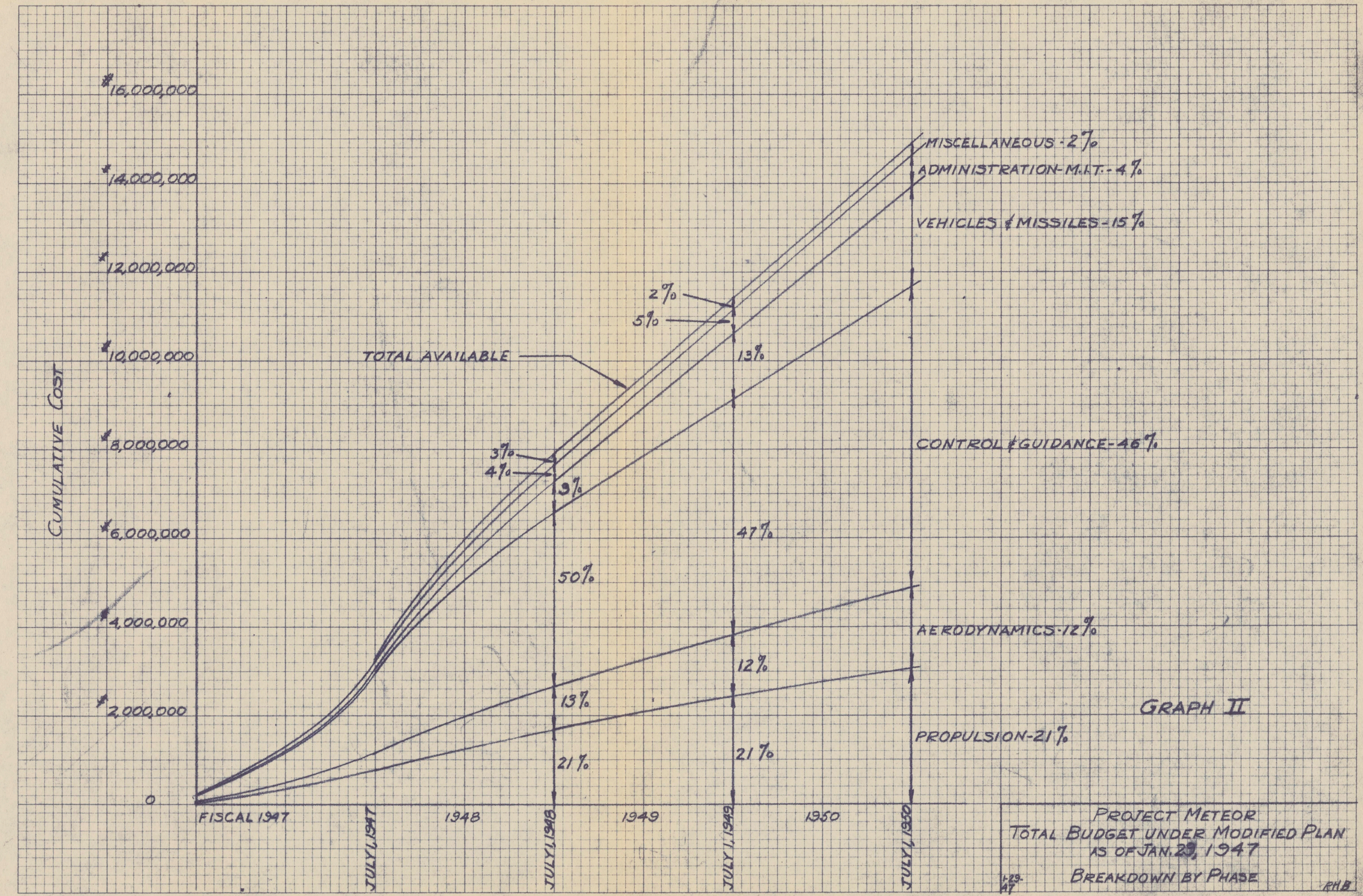

GRAPH II

PROJECT METEOR
TOTAL BUDGET UNDER MODIFIED PLAN
AS OF JAN. 29, 1947
BREAKDOWN BY PHASE

1-29-47 RHB

EUGENE DIETZGEN CO.
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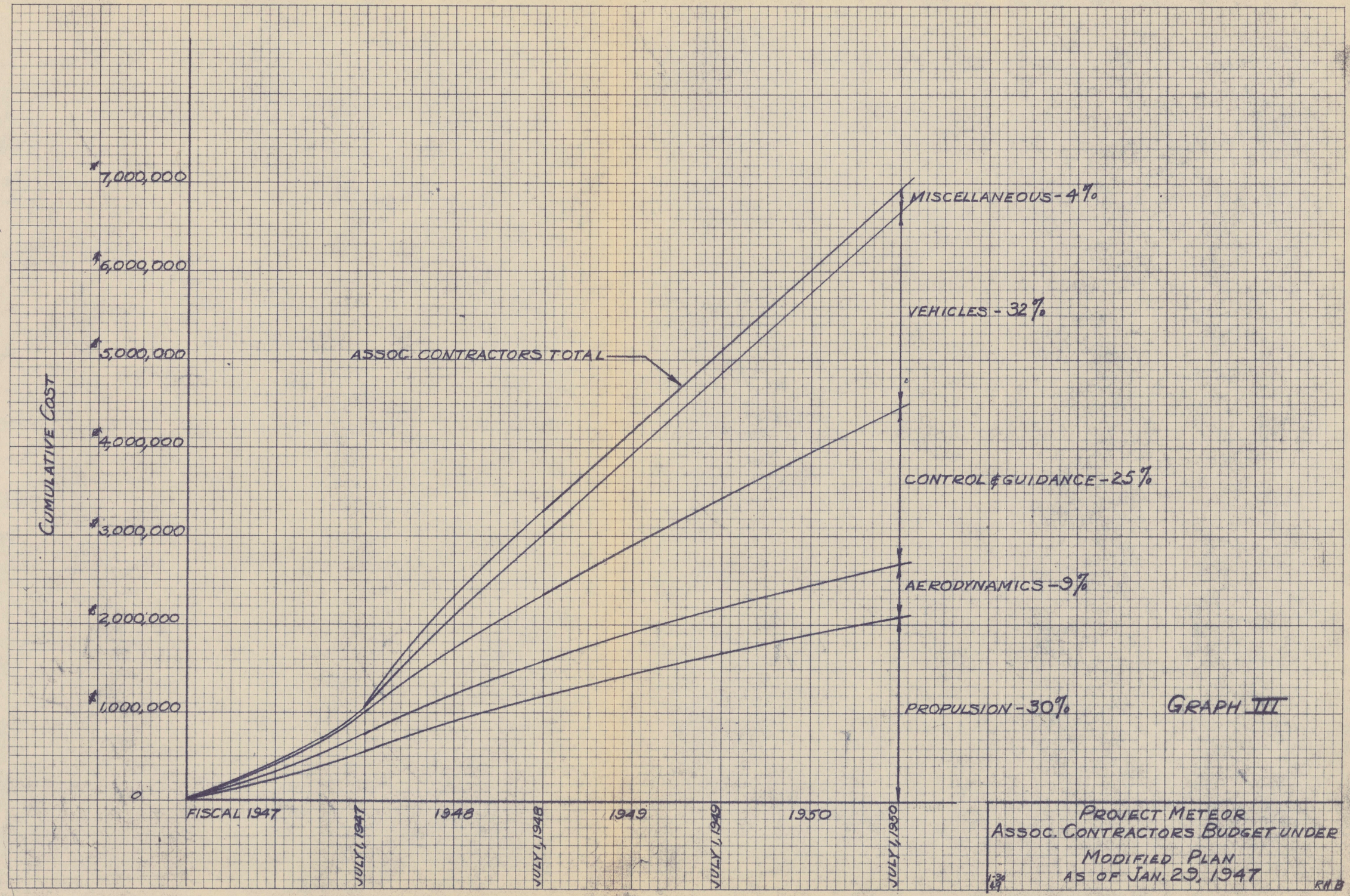
10 X 10 PER INCH



GRAPH III

PROJECT METEOR
ASSOC. CONTRACTORS BUDGET UNDER
MODIFIED PLAN
AS OF JAN. 29, 1947

RMB

EUGENE DIETZGEN CO.
MADE IN U.S.A.

NO. 340D-10 DIETZGEN GRAPH PAPER
10 X 10 PER INCH

$8,000,000
$7,000,000
$6,000,000
$5,000,000
$4,000,000
$3,000,000
$2,000,000
$1,000,000
0

CUMULATIVE COST

M.I.T. TOTAL

ADMINISTRATION - 9%

GUIDANCE - 26%

CONTROL - 39%

AERODYNAMICS - 14%

PROPULSION - 12%

FISCAL 1947

JULY 1, 1947

JULY 1, 1948

JULY 1, 1949

JULY 1, 1950

GRAPH IV

PROJECT METEOR
M.I.T. BUDGET UNDER MODIFIED PLAN
AS OF JAN. 29, 1947.

1-31-47

RHB

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MAY 5 1947
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Guided Missiles
Mem

M.I.T.
GUIDED MISSILES PROGRAM
PROJECT METEOR

Vol. I No. 1 — Weekly Calendar — May 2, 1947

Monday - May 5 — 11 AM - 3 PM - Rm. 20-B-245 — Joint meeting of Meteor Executive Committee, technical leaders of U.A.C. and Bell.
Visitors: John G. Lee, U.A.C.
D. R. Shoults, Bell
R. J. Sandstrom, Bell

Tuesday - May 6 — 3 - 5 PM - Rm. 1-390 — Aeronautics Seminar: "Plastic Flow and Fracture of Metals", Professor C. W. MacGregor

Wednesday - May 7 — Visit of British Group
Air Commodore J.G.Franks, RAF, Director of Research and Development (Air), Ministry of Supply,
Dr. W. Cawood, Director of Guided Weapons, Ministry of Supply,
Group Captain F.G.S. Mitchell, RAF, British Supply Office,
Sir Alwyn Crow, British Supply Office,
Mr. S. J. Curtis, British Supply Office,
Col. E. H. Salzman, USMC,
Luncheon in Silver Room at 12:30 with Policy Committee, Executive Committee and Navy Representatives.

Thursday - May 8 — 1:00 PM - Ramjet Test Vehicle conference at M.I.T. with U.A.C. representatives.

Friday - May 9 — 4:30 PM - Rm. 20E-225 — Dynamic Analysis and Control Laboratory, Engineering Seminar.
Subject: Synthesis of the Accelerometer - S. B. Williams. (Accomodations limited - please call R. E. Kimball, Ext. 2332 if you wish to attend.)

Monday - May 12 — 12 - 2 PM - Rm. 20B-245 — Regular Meeting - Meteor Executive Committee

Tuesday - May 13 — 3 - 5 PM - Rm. 1-390 — Aeronautics Seminar: "Plastic Waves" Dr. Theodore Von Karman

Tuesday - May 13 — Combustion Meeting with U.A.C. at E. Hartford. Professors Hottel, Williams, Mr. Blinman, Mr. Whitman and Mr. Baker attending.

Monday - May 19	12 - 2 PM - RM 20B-245	Regular Meeting - Meteor Executive Committee
Thursday - May 22	4 PM - Rm. 2-390	Metallurgy Department Colloqium - "Sweat Cooling", Dr. Pol Duwez
		(NOTE: Originally scheduled for May 15)

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M.I.T.
GUIDED MISSILES PROGRAM
PROJECT METEOR

Vol. I No. 2

Weekly Calendar

May 9, 1947

Monday - May 12	12 - 2 PM Rm. 20B-245	Regular Meeting - Meteor Executive Committee
Tuesday - May 13	3 - 5 PM Rm. 1-390	Aeronautics Seminar: "Plastic Waves" Dr. Theodore Von Karman
Tuesday - May 13		Combustion Meeting with U.A.C. at E. Hartford. Professors Hottel, Williams, Mr. Blinman, Mr. Whitman and Mr. Baker attending.
Thursday - May 15	4 PM - Rm. 2-390	Metallurgy Department Colloqium - "Sweat Cooling", Dr. Pol Duwez
Monday - May 19	12 - 2 PM - Rm. 20B-245	Regular Meeting - Meteor Executive Committee
Monday - May 26	11 - 3 PM - Rm. 20A-119	Joint Meeting of Meteor Executive Committee, BuOrd, U.A.C., and Bell representatives - Technical Administration Problems Visitors: Comdr. H. M. Mott-Smith, BuOrd Mr. W. E. Brown, Bell Mr. R. J. Sandstrom, Bell Mr. D. Roy Shoults, Bell Mr. John G. Lee, U.A.C.
Thursday - May 29	4 PM - Rm. 2-390	Metallurgy Department Colloqium - "Thermal Shock Resistant Ceramics", Professor F. H. Norton

Revised
5-15-47

MIT GUIDED MISSILES PROGRAM
Room 20-B-245

Report of Conference Held at Massachusetts Institute of Technology
Bell Aircraft, United Aircraft, Bureau of Ordnance, MIT

December 18, 1946

A conference between representatives of the Bureau of Ordnance, Bell Aircraft Corporation, United Aircraft Corporation, and MIT was held at MIT for the purpose of discussing various testing facilities that have been proposed for use in the Meteor program. The following people were present at the meeting:

BuOrd:
O. N. Spain, Jr.

BuOrd, MIT:
F. W. Kinsley
L. W. Sharpe

Bell:
W. E. Brown
C. Lynn
J. F. Strickler, Jr.

UAC:
W. A. Kuhrt
J. G. Lee

MIT:
H. C. Hottel
J. R. Markham
H. G. Stever
Helen Wenetsky
B. Whitman
G. C. Williams

I. FIELD-TESTING FACILITIES

Commander Spain of the Bureau of Ordnance described the field-testing facilities that are now available for use by Project Meteor, and outlined the relative advantages and disadvantages of each. Stations that have such facilities are located at:

A. Camp Davis, North Carolina
B. White Sands
C. Inyokern
D. Point Mugu

A. 1. At the present time, Camp Davis is not a Naval Station but is being contractor-operated for the Bureau of Ordnance by Kellex Corporation.

2. The firing track is 15° off the beach and the missile will land in the water. It was pointed out that this was a disadvantage since it would be preferable to use a site where the missile would be recoverable.

3. There are eight observation towers located along the beach. These will be completely equipped for instrumentation (some radar and some optical) and they can all be interconnected. The instrumentation will be installed by March 1947 and accurate tracking can be done for a 25-mile range.

4. It is expected that firing will not be held up more than three days a month because of weather difficulties.

B. Weather conditions at White Sands are very favorable, and firing would be held up no more than a few days a year for this reason. It is well equipped for the study of long-range firing (up to 90 miles). Up to the present time, it has been run as a missile testing area by the Army Ordnance Department, but a Naval Unit is now being set up. The firing range is in the sand and there is therefore a good chance of recovering the missile. The range is only instrumented at the present time for tracking missile trajectories at short ranges and to high altitudes. Plans now are under way to instrument the first 50 miles of the range for completion by January 1948.

C. Inyokern is the best instrumented and most completely set up of the missile-testing areas. Because of this very reason, however, scheduling difficulties may be encountered. Weather conditions are very good and for only a few days a year would the weather interfere with firing tests. The shop facilities at this station are better than at the others and BuOrd has the primary interest there. However, the maximum range for which Inyokern is instrumented is 25 miles.

D. The Bureau of Aeronautics has the primary interest at Point Mugu. More interference from the weather will probably be encountered here than at the other stations--possibly five or six days a month will be unavailable for firing tests because of this cause alone. In addition there may be more trouble from sea traffic, and it may be difficult to land a large plane there.

It was felt that it would be advisable to use only one station for testing if possible. Therefore, it is advisable that all the available data on these testing areas be obtained before a decision is made. It was recommended that:

A. A weather analysis be made for all four stations.

B. Data compiled by the Joint Research and Development Board regarding these stations be obtained.

C. A rough comparison be obtained of the probable status of these facilities at the time when they will be used.

D. An attempt be made to determine what other contractors will be having missiles come up for firing at the stations at the same time that the Project Meteor missiles are to be tested.

After the results of these studies have been obtained, another meeting will be held at which a definite missile-testing area will be decided upon.

II. TEST FACILITIES

A. Introduction

When Project Meteor was first established, funds were not available for the erection of additional facilities, and work was planned on the basis of existing equipment. For the remainder of this fiscal year funds are still strictly limited to projects, and if facilities are to be established, the money must be charged up to IRNV (increased replacement of naval vessels) at the expense of additional equipment for naval vessels. A request for funds for facilities during the next fiscal year has been made, but this request has not yet been acted on by Congress.

At the present time, if an additional facility is requested, a thorough study of the requirements must be made, and all the advantages and disadvantages must be considered. After a complete proposal has been drawn up and approved by Re9, it is submitted to the Contract Section of the Research Division for review. Following this, the Shore Establishment Division reviews it and tries to coordinate it into existing BuOrd facilities. It is then necessary to obtain approval from Admiral Hussey. After that, the request goes to the Chief of Naval Operations and the Home Base Development Board who attempt to coordinate it into the facilities of all the various technical bureaus. It is finally submitted to the Secretary of the Navy and thence to the Joint Research and Development Board for final approval. If approval has been secured all along the line, the Bureau of Yards and Docks then takes over the details of construction.

The Bureau of Ordnance may, however, directly authorise the spending of a reasonable amount of money for architect and engineering expenses encountered in determining the cost of various facilities.

B. MIT Facilities

Last spring, BuOrd indicated that there would be funds available for the construction of a Supersonic Laboratory at the Institute. Accordingly, MIT prepared a proposal outlining the plans for this laboratory, which is described in the next paragraph, and this proposal has since been approved. Later, it was requested that a proposal be drawn up indicating all the additional facilities that might be required during the next year. This has been done only in a rough way, and includes requests for a Combustion Laboratory and for an Electronic and Control Laboratory.

1. Supersonic Laboratory

Some time ago, plans were made and private funds secured for the construction of a supersonic facility at MIT for the testing of gas turbines. This supersonic wind tunnel is not, however, large enough to do aerodynamic work.

Therefore, a request for a supersonic laboratory to be provided

from Project Meteor funds has been made and approval has been granted. The wind tunnel is to be 3 square feet in cross section and can be used for Mach numbers up to 2.5. It is a closed return tunnel and therefore cannot be used for combustion work. A great deal of engineering time has already been spent and the equipment fields have been investigated. The building has in effect been designed and the general layout established. It is expected that the motors and compressors to be used will be settled by the end of this week. Although the primary purpose of the tunnel is to devote time to aerodynamic studies with regard to Project Meteor, it can also be used for educational purposes and for applied research.

The estimated cost of the tunnel is $2,600,000, and it is believed that calibration of the tunnel can start about 18 months after the breaking of ground.

2. Combustion Facility

At the present time, combustion facilities at MIT are wholly inadequate. Three air supplies are available: one at 5 lbs/sec at pressures less than 15 psig, which is adequate only for the preliminary stage of ramjet-burner stabilization studies; one at $\frac{1}{2}$ lb/sec at a pressure of 100 lb. psi, which is used for air atomization studies; one subatmospheric-pressure air supply which can go down to 1/3 or 1/4 of an atmosphere, and which has a velocity of 300 ft/sec in a 6-inch test section. These air supplies are all useful but it is impossible to get air velocities that are sufficiently high for even a small ramjet unit. In addition to this difficulty, the space needs are very great, and the educational feature particularly is being neglected because of lack of space.

Plans for a new facility call for an air supply at 15 lbs/sec up to a pressure of 150 psi. A layout is required that will provide enough versatility to allow a number of small research developments to be carried out at the same time. There are to be four soundproof test cells, a large cross section manifold, provision for exhaust tankage on two of the cells, but no provision for pumping out of the tankage. Since intermittent operation will be satisfactory for most of the work planned for this facility, separate storage tankage should be available. However, for special work, the building is to be close-coupled to the Supersonic Laboratory and present plans call for piping connections to the supersonic tunnel air supply. Large sound-absorbing stacks are needed, and the problem of vibration effects must be studied.

There is an immediate need for this facility as a higher velocity air supply could be used right now for ramjet stabilization work. The expected cost is $400,000 and four to six months will be required for construction.

3. Electronic Facility

A new building is needed to house the electronic and control departments, which are growing rapidly. The only equipment that will be needed will be electronic equipment, test benches, and laboratory supplies. At a later date, facilities will have to be provided for setting up the large flight

simulator. For later stages of the guidance problem, it will also be necessary to install radar roof systems. The size of the building will be determined by the size of the control group and of the electronic group, which are expected to consist of about 100 men each. The equipment required is relatively straightforward.

The building will be required in about a year, but the time element is not as urgent as that for the combustion and supersonic facilities. The cost is estimated at about $1,000,000.

C. Bell Aircraft Corporation Facilities

Bell Aircraft Corporation has been using rocket test facilities in a group of buildings that had been available to them during the war. However, these test cells are no longer the property of Bell and the War Assets Administration has proposed selling them to the city of Niagara Falls for use as hangars. They will therefore be unsatisfactory for their present purposes.

In addition, the aerodynamics group have been planning a supersonic tunnel that will be relatively inexpensive because it will use existing power.

The electronic facilities planned do not require additional buildings, and only involve the changing of partitions, setting up of test benches, and additional wiring.

1. Supersonic Tunnel

It will be possible to use this tunnel as a wind tunnel in the usual manner. In addition, since it will have an open return, preheaters, and an air dryer, it can be used to test models with exhaust discharge at supersonic speeds, and can provide temperatures comparable with those found at high altitudes. It will be used to test rockets and ramjets, and to study the influence of the jet on flow conditions around the tail and on the control surfaces as well as to serve as an aerodynamic test tunnel. It is felt that aerodynamic tests made before and during the design will make it possible to fire fewer complete missiles before reaching a satisfactory configuration and will therefore be more economical in the long run.

The tunnel is to be located in an existing building to which steam is already piped. The preliminary estimate of cost is $150,000 - $200,000, but Bell would like authorization to have a more complete cost estimate made.

2. Rocket-Test Facility

It is imperative that adequate facilities be available for developmental and production testing of rockets. As stated previously, the present test cells can no longer be used for this purpose. The lack of a building is

slowing up the work since full-scale operation is impossible in the present test cells because of the hazards and the lack of security, and because of the difficulty in adapting engine test cells to the testing of rockets. A request has been forwarded to the Bureau of Ordnance for the building of temporary walls around the individual test cells now being used so that they may be operated with greater safety. This improvement will cost approximately $3000.

In view of these restrictions a new building is being planned. This will contain 8 or 9 test stands, control rooms servicing 2 test stands each, room for running turbine pumps, space for a small hydraulics laboratory and for a small chemical laboratory. The building cannot be located in the present plant because of danger to personnel and it will be necessary to take adequate safety and fire precautions in the new building.

Initial drawings are being prepared and will be ready in six weeks. The estimated cost of the building is $250,000.

As a temporary measure, it is hoped that a string of test cells which will eventually be incorporated into the final building, can be erected for about $40,000.

3. Electronics Facilities

The present electronic facilities are quite small and do not provide enough space for the work necessary in the design and testing of control and telemetering systems. To satisfy the requirements of this department, no actual construction is necessary. It is merely necessary to move partitions and to install additional wiring, test benches, etc. A flight simulator, which can be used for Project Meteor, is being built but the charge for this is allocated to an Army project.

The estimated cost of this facility is $32,000, $10,000 of which will probably not be expended if two recording oscillographs can be provided as government furnished equipment. The possibility of sharing this cost with the Army project at Bell has been discussed and it is believed that an arrangement of this kind can be worked out.

Commander Spain indicated that this type of expense could probably be taken out of the present project funds.

D. United Aircraft Corporation

At first, plans for Project Meteor at United Aircraft Corporation were made on the assumption that it would be wise to go slowly on the erection of new facilities, but it is now apparent that it is necessary to obtain these facilities as soon as possible to ensure effective research and development.

In order to consolidate the requirements, the possibility of combining the combustion and supersonic facilities was considered, but it was found that, although this was possible, it was just as costly and was more time-consuming than to have two separate facilities.

United Aircraft is planning to subcontract as much of its electronic work as possible, and to maintain only a small electronics group. Therefore, the need for electronic facilities is negligible.

1. Supersonic Tunnel

A study was made of possible sites for the UAC supersonic tunnel, and it was felt that the Eastern Gas and Fuel Association Plant at Everett, Massachusetts, offered the best available site east of the Mississippi. The boilers at this plant supply steam to a coke plant which provides illuminating gas for the city of Boston. The excess steam supply was originally intended to run blowers that were to operate the blast furnaces of a steel-producing plant but this plan has since been abandoned as being inefficient. The air supply, which provides 400,000 lbs. of air an hour, is therefore available for use by UAC in its supersonic tunnel.

Present plans call for a test section 12" x 16" if one compressor is used and 24" by 16" if two compressors are used. The tunnel will be capable of being used at Mach Numbers up to 2.6. It will have an open return, but no air-drying equipment since it is felt that the temperature can be kept high enough by preheating. It will be used to study the effects of combustion on external air flow and the effects of external air flow on combustion, and will be mostly concerned with aerodynamic data. It will have a larger throat size than the proposed Bell tunnel because the larger size is needed for the testing of ramjets, but it will not be capable of as high a speed as the Bell tunnel.

The tunnel is being designed so that it can be transportable and can be moved to any other blast-furnace air supply.

A specific proposal as to how the cost will be handled is expected to be available within a few days, but it is believed that the cost will not be more than $200,000. It will be possible to have the tunnel in operation without a balance within a period of six months.

2. Practical Burner Stand

It is essential that a manufacturing contractor have test facilities at his own disposal. These preliminary testing facilities are needed to permit the manufacturer to check out the general performance of a combustion chamber.

The proposed facility is to utilize two two-stage engines (P&W R-2800's) and to use the second stage as an air compressor. Those engines may be operated in parallel or in series. They can be set up adjacent to the present labora-

tory without much of a building around them. If surplus engines could be obtained from the Navy, only the piping charges would have to be charged to the project.

The cost of this facility cannot be determined yet because of the uncertainty of the exact requirements and the lack of knowledge as to the cost of the engines.

3. Rocket Test Facility

It is hoped that any tests that must be run on the rocket motors used for the aerodynamic vehicle can be made at Bell Aircraft, and thus the need for a rocket test facility can be obviated. Representatives of Bell Aircraft indicated that such an arrangement could in all probability be made.

4. Ultimate Combustion Stand

The requirements for combustion test equipment are not yet known and therefore no estimates can be made as yet.

E. Summary and Comparison

1. Electronic Facilities

Since the required electronic facilities at both Bell and United Aircraft are relatively inexpensive, there is not expected to be an overlapping of test equipment in this field.

2. Combustion Facilities

The Practical Burner Stand at United Aircraft and the Rocket Test Facility at Bell Aircraft are both needed since, for efficient operation, the manufacturer must have at his own disposal such preliminary testing facilities. This need cannot be filled by the MIT Combustion Facility, which is to be operated intermittently since continuous operation is needed for manufacturing tests, particularly fatigue and reliability tests, although intermittent operation may be sufficient for applied research problems.

Furthermore, the Combustion Facility at MIT and the Bell and UAC tunnels are designed to test different things. For example, the Everett tunnel will be primarily interested in aerodynamic data and investigating supersonic flow and is called a combustion tunnel only to distinguish it from the closed-return type of tunnel where no combustion is possible. On the other hand, the MIT Combustion Facility will be used for tests of combustion, ignition, etc. The UAC tunnel requires a larger throat cross section than the Bell tunnel because of the difference in the requirements for testing ramjets as against those for testing rockets. In addition, the Bell tunnel differs from the UAC tunnel in that it has a higher speed and lower density, and therefore provides a different type of information.

If a single facility were to be designed to combine the tasks of the two subcontractors, it would cost much more than the single facilities combined because of the great increase in complexity.

3. Supersonic Facilities

A comparison of the facility requirements at MIT, Bell, and UAC, from the aerodynamic rather than the combustion viewpoint, has been prepared and is outlined in the attached memorandum.

HW:KD

cc: Policy Committee
Executive Committee
J. G. Lee, UAC
C. J. McCarthy, UAC
D. R. Shoults, Bell
W. E. Brown, Bell
G. W. Tuttle
F. W. Kinsley
L. W. Sharpe
BuOrd via Mr. Sharpe

Discussion of Supersonic Test Facilities for Project Meteor

The objective of any test facilities for Project Meteor is to obtain the greatest amount of useful data in the shortest time for the least expense. To do this it appears that three separate supersonic facilities under guidance of MIT, Bell, and UAC respectively will be more advantageous than any combined facility for the following reasons:

1. The tunnels are complementary, not duplicate
2. Separate tunnels will be available before any possible combined unit
3. Separate tunnels will provide more data
4. Separate tunnels will cost less than a combined unit
5. The construction of several separate tunnels is good long range policy

1. The tunnels are complementary, not duplicate

a) The MIT tunnel, being a closed circuit, can vary density and humidity, but can not test models containing heat or exhaust discharge

b) The Bell tunnel, having an open return, preheaters, and air dryer, can test models with exhaust discharge, and can provide altitude temperatures. It has a Mach number of 4.0 or somewhat higher compared with 2.5 to 2.6 for MIT or UAC.

c) The UAC tunnel, having an open return and preheaters, but no air dryer, can also test models having exhaust discharge. Its throat size of 2.6 sq. ft. is approximately double the Bell throat and 2/3 of the MIT throat.

d) None of the three units are suitable for pure research in combustion where hot walls and extraordinary provisions are required for silencing and the elimination of explosion hazards, and air dryers and balance equipment are not required.

e) Tunnels of the intermittent type, such as Koehel, while suitable for strictly aerodynamic testing, are not satisfactory for testing where heat is present in the model, since they do not provide time for the temperature to stabilize.

2. Separate tunnels will be available before any possible combined unit

a) The power supplies are now available for the Bell and UAC tunnels at their respective locations.

b) Any "all purpose" equipment is universally found to be more complicated, and therefore time-consuming, to design or to operate. Coordination between the interested agencies to produce a compromise design would delay starting several months.

c) A combustion stand for research purposes will require considerable time to erect due to the heavy structure required to safeguard against explosion hazards. Hence combining this type of stand with the supersonic equipment will cause appreciable delay.

3. Separate tunnels will provide more data

a) Since each tunnel is specialized, a greater variety of test conditions can be investigated.

b) Failure of any one tunnel, or its associated equipment, or power supply, would not tie up the whole Meteor program

c) The UAC and Bell tunnels which will be operating a year in advance of the MIT tunnel, can, between them, serve as prototypes for certain of the MIT nozzle, balance, and accessory designs.

d) In cases of emergency, three tunnels, each working two or more shifts, can produce much more data than a single tunnel. Such emergencies will arise, not only in time of war, but whenever trouble is experienced in the missile firing program.

e) With several separate tunnels, short rush programs can be accommodated without disrupting basic research.

f) With separate tunnels, the various programs can proceed concurrently. They need not be delayed for completion of the other programs.

4. Separate tunnels will cost less than a combined unit

a) Since neither the Bell or UAC tunnel proposals have standby charges (the power is available anyhow) it costs the same to operate two tunnels on a one-shift basis than one tunnel on a two-shift basis.

b) Operation is cheaper on a single shift basis because modification of the model or test equipment, which are the principal source of delay, can be carried out by a small night force. On a combined tunnel operating on a two-shift basis, these delays tie up the second shift.

c) The construction of two tunnels, each designed to fit the local conditions, is obviously less expensive than a combined unit, having the best features of both. For example, to provide the UAC size throat for the Bell Mach number would roughly double the steam capacity for Bell, and this would require new boilers; while to provide a Mach number of 4.5 in the UAC tunnel would require the addition of steam injectors and dryers of over double the capacity of the Bell tunnel.

5. The construction of several separate tunnels is good long range policy

a) There is now an acute shortage of supersonic test facilities which will become worse as the various guided missile study programs reach the design stage. This is exemplified by the two to three year backlog of work at Daingerfield

on the Bumblebee program alone, and by theobvious lack of fundamental design data.

b) The cost of misfiring two or three missiles will cover the entire outlay for a tunnel such as the Bell or UAC proposal. The cost of firing missiles will increase as their size and complexity develop.

c) The sound development of guided missiles requires the establishment of several groups of engineers having ready access to and experience in operating, adequate test facilities to provide decentralization in case of war.

d) The Bell tunnel, located convenient to Bell's engineering and experimental departments, situated away from the coast, admirably fits this decentralization picture. The UAC tunnel which is reasonably convenient for both MIT and UAC has the further advantage of being transportable to any other blast furnace air supply in the central portion of the United States.

e) The establishment under a central coordinating agency of several competitive research teams will give the government more effective results than can be obtained from a large central agency.

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GUIDED MISSILES PROGRAM
PROJECT METEOR

Vol. I No. 3 — Weekly Calendar — May 16, 1947

Monday - May 19	12 - 2 PM - Regular Meeting - Meteor Executive Committee Rm. 20B-245
Wednesday - May 21	Rocket Propulsion Conference with Bell Aircraft at Niagara Falls, Professor Satterfield, Mr. Collins, Mr. Whitman attending.
Monday - May 26	11 - 3 PM - Joint Meeting of Meteor Executive Committee, Rm. 20A-119 BuOrd, U.A.C., and Bell representatives - Technical Administration Problems Visitors: Comdr. H. M. Mott-Smith, BuOrd Mr. W. E. Brown, Bell Mr. R. J. Sandstrom, Bell Mr. D. Roy Shoults, Bell Mr. John G. Lee, U.A.C. Mr. C. J. McCarthy, U.A.C.
Thursday - May 29	4 PM - Metallurgy Department Colloqium - Rm. 2-390 "Thermal Shock Resistant Ceramics", Professor F. H. Norton
Monday - June 2	12 - 2 PM - Regular Meeting - Meteor Executive Committee Rm. 20B-245

MIT GUIDED MISSILES PROGRAM

May 26, 1947

To: Members of the Executive Committee

Professor Stratton	Mr. Whitman
Professor Hall	Professor Wiesner
Professor Hottel	Professor Williams
Professor Markham	Professor Zimmerman

From: H. Guyford Stever

Subject: Dr. Schneider's Visit

I telephoned Ed Schneider to invite him here on Thursday, May 29 and he has accepted.

When he arrives, I'll get in touch with you to arrange conference time.

HGS:KD

cc: J. R. Killian, Jr.
N. McL. Sage
E. R. Gilliland
J. C. Hunsaker
E. L. Moreland
T. K. Sherwood

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