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REPRESENTATIVE OPERATING CHARTS OF PROPELLERS TESTED

IN THE NACA 20-FOOT PROPELLER-RESEARCH TUNNEL

By W. H. Gray and Nicholas Mastrocola

Langley Memorial Aeronautical Laboratory
Langley Field, Va.

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

ADVANCE RESTRICTED REPORT

REPRESENTATIVE OPERATING CHARTS OF PROPELLERS TESTED

IN THE NACA 20-FOOT PROPELLER-RESEARCH TUNNEL

By W. H. Gray and Nicholas Mastrocola

Extensive tests of full-scale propellers have been made in the 20-foot propeller-research tunnel (PRT) at the Langley Memorial Aeronautical Laboratory during its many years of operation. The results were usually presented in the form of charts showing thrust coefficient, power coefficient, and efficiency, each plotted separately against V/nD . The type of chart now being employed by airplane and propeller manufacturers for performance estimates consists of power coefficients plotted against V/nD with lines of constant efficiency superimposed. As a result of numerous requests to issue this type of chart directly and on a large scale, the present report has been compiled from data taken from a series of fairly recent reports. Charts are presented only for the conditions considered to be useful in present-day design (see table I), although charts covering other conditions have been developed and are available.

In the preparation of the plots presented, the data were cross-faired and do not necessarily check exactly the previously published data. The power coefficients of all dual-rotating propellers in this report represent the sum of the power coefficients of the front and rear propellers and are for the test conditions in which blade angles of the front and rear propellers were set to absorb approximately equal power at peak efficiency only.

The usual coefficients and symbols have been used and are defined as follows:

$$C_P \quad \text{power coefficient} \quad \left(\frac{\text{engine power}}{\rho n^3 D^5} \right)$$

$$C_T \quad \text{thrust coefficient} \quad \left(\frac{\text{effective thrust}}{\rho n^2 D^4} \right)$$

$$\eta \quad \text{propeller efficiency} \quad (C_T/C_P) (V/nD)$$

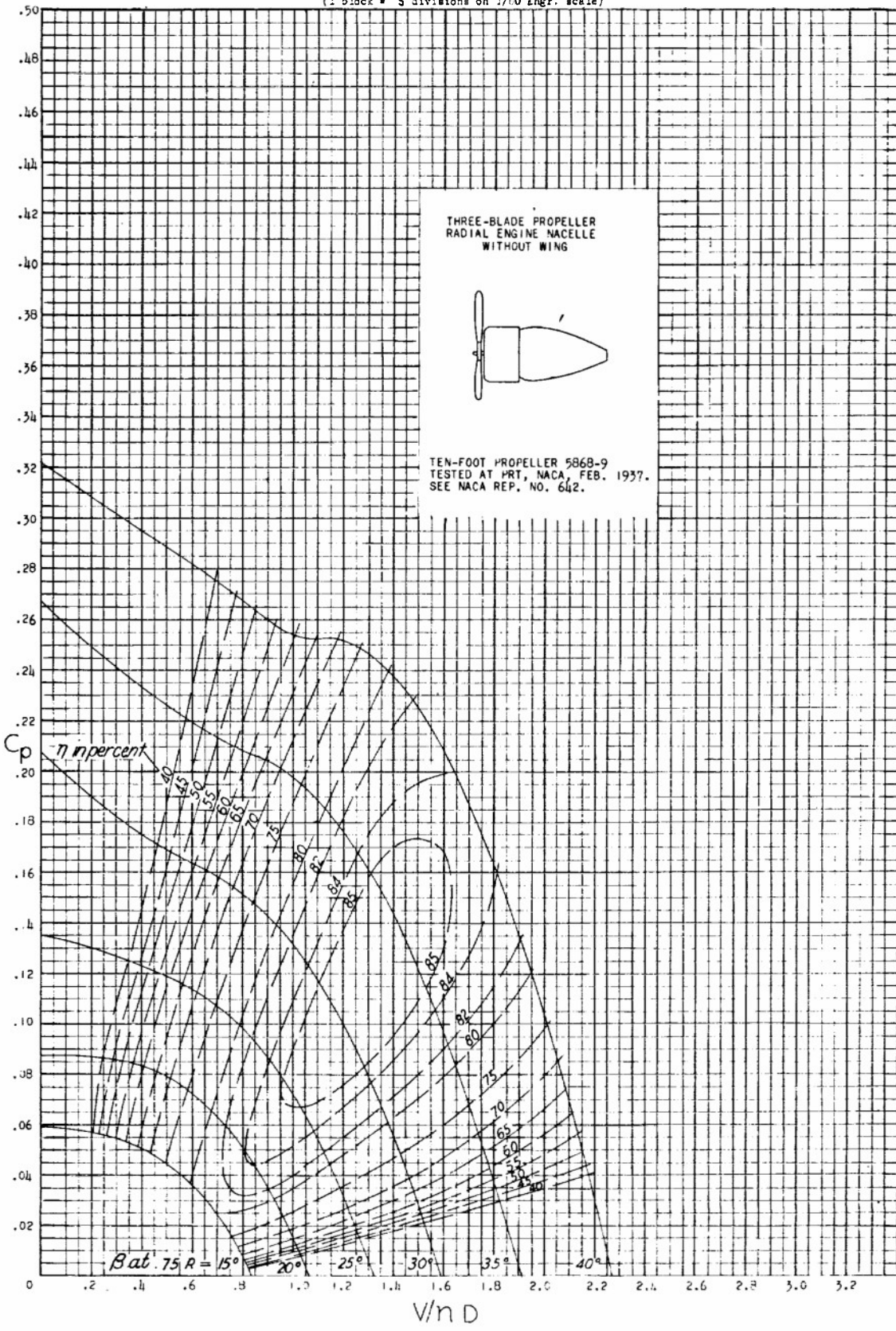
and

$$\rho \quad \text{mass density of air, slugs per cubic foot}$$

| Figure | Blade activity factor | Number of blades | Rotation | Propeller location | Body configuration | Reference |
|---|-----------------------|------------------|----------|--------------------|---|--|
| Blade design, Bureau of Aeronautics 5868-9 | | | | | | |
| 1 | 80 | 3 | Single | Tractor | Radial-engine nacelle without wing | Biermann, David, and Hartman, Edwin P.: Tests of Five Full-Scale Propellers in the Presence of a Radial and a Liquid-Cooled Engine Nacelle, Including Tests of Two Spinners. Rep. No. 642, NACA, 1938. |
| 2 | 80 | 3 | --do-- | --do-- | Liquid-cooled engine nacelle without wing | Biermann, David, and Hartman, Edwin P.: Tests of Two Full-Scale Propellers with Different Pitch Distributions, at Blade Angles up to 60°. Rep. No. 658, NACA, 1939. |
| Blade design, Hamilton Standard 3155-6 and 3156-6 | | | | | | |
| 3 | 90 | 2 | Single | Tractor | Streamline nacelle without wing | Gray, W. H.: Wind-Tunnel Tests of Single- and Dual-Rotating Tractor Propellers at Low Blade Angles and of Two- and Three-Blade Tractor Propellers at Blade Angles up to 65°. NACA A.R.R., Feb. 1943. |
| 4 | 90 | 3 | --do-- | --do-- | -----do----- | Biermann, David, Hartman, Edwin P., and Pepper, Edward: Full-Scale Tests of Several Propellers Equipped with Spinners, Cuffs, Airfoil and Round Shanks, and NACA 16-Series Sections. NACA A.C.R., Oct. 1940. |
| 5 | 90 | 3 | --do-- | --do-- | Streamline nacelle with wing | Gray, W. H.: Wind-Tunnel Tests of Single- and Dual-Rotating Tractor Propellers at Low Blade Angles and of Two- and Three-Blade Tractor Propellers at Blade Angles up to 65°. NACA A.R.R., Feb. 1943. |
| 6 | 90 | 4 | --do-- | --do-- | -----do----- | Biermann, David, and Hartman, Edwin P.: Wind-Tunnel Tests of Four- and Six-Blade Single- and Dual-Rotating Tractor Propellers. Rep. No. 747, NACA, 1942. |
| 7 | 90 | 4 | --do-- | --do-- | -----do----- | |
| 8 | 90 | 6 | --do-- | --do-- | -----do----- | |
| 9 | 90 | 8 | --do-- | --do-- | -----do----- | Biermann, David, and Gray, W. H.: Wind-Tunnel Tests of Eight-Blade Single- and Dual-Rotating Propellers in the Tractor Position. NACA A.R.R., Nov. 1941. |
| 10 | 90 | 3 | Single | Pusher | Streamline nacelle without wing | Biermann, David, and Gray, W. H.: Wind-Tunnel Tests of Single- and Dual-Rotating Pusher Propellers Having from Two to Eight Blades. NACA A.R.R., Feb. 1942. |
| 11 | 90 | 4 | --do-- | --do-- | -----do----- | |
| 12 | 90 | 6 | Dual | --do-- | -----do----- | |
| 13 | 90 | 8 | --do-- | --do-- | -----do----- | |
| Blade design, Hamilton Standard 3155-6-1.5 and 3156-6-1.5 | | | | | | |
| 14 | 135 | 3 | Single | Tractor | Streamline nacelle with wing | Biermann, David, Gray, W. H., and Maynard, Julian D.: Wind-Tunnel Tests of Single- and Dual-Rotating Tractor Propellers of Large Blade Width. NACA A.R.R., Sept. 1942. |
| 15 | 135 | 4 | --do-- | --do-- | -----do----- | |
| 16 | 135 | 6 | Dual | --do-- | -----do----- | |
| 17 | 135 | 8 | --do-- | --do-- | -----do----- | |

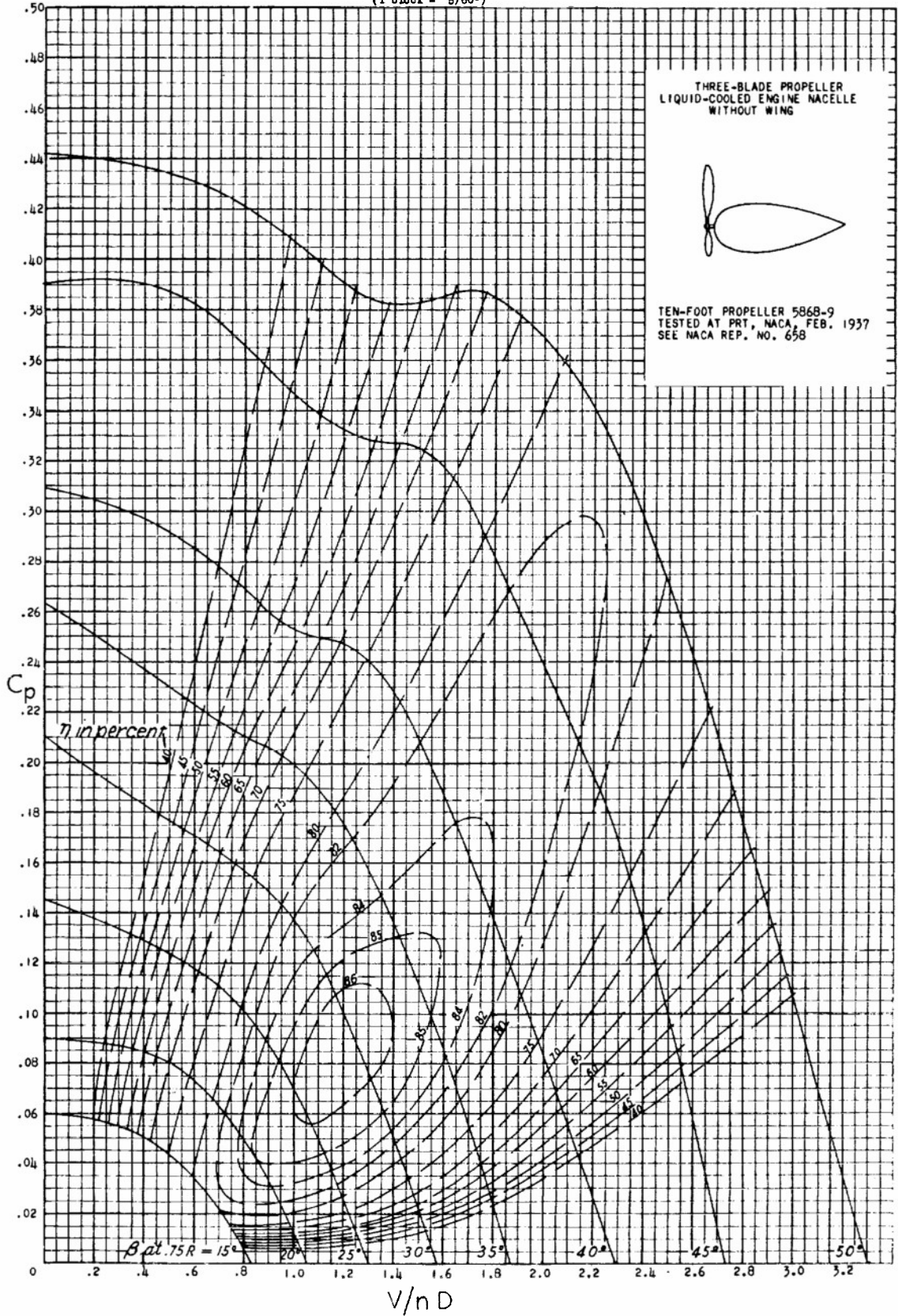
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4-286

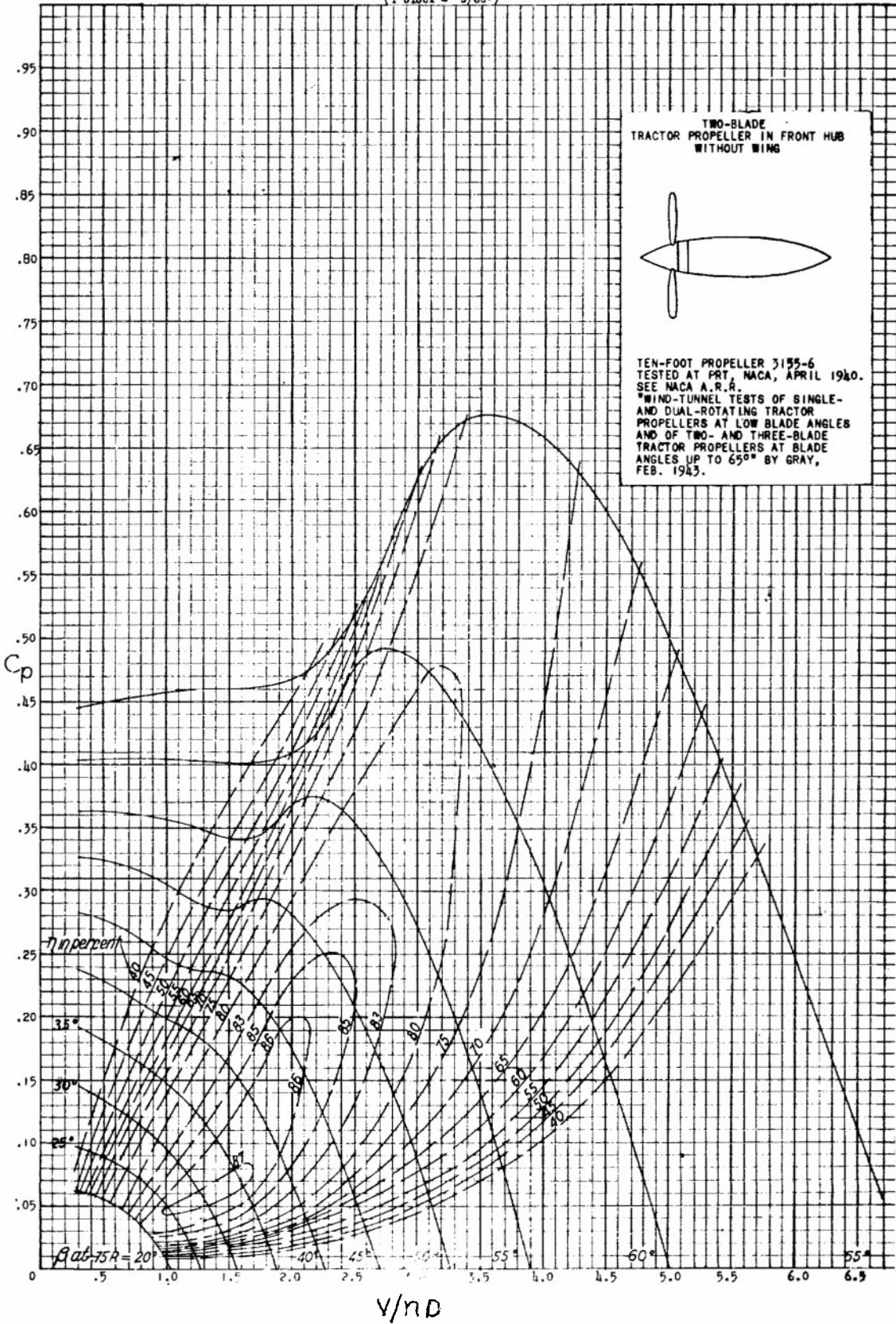


(1 block = 5/60°)

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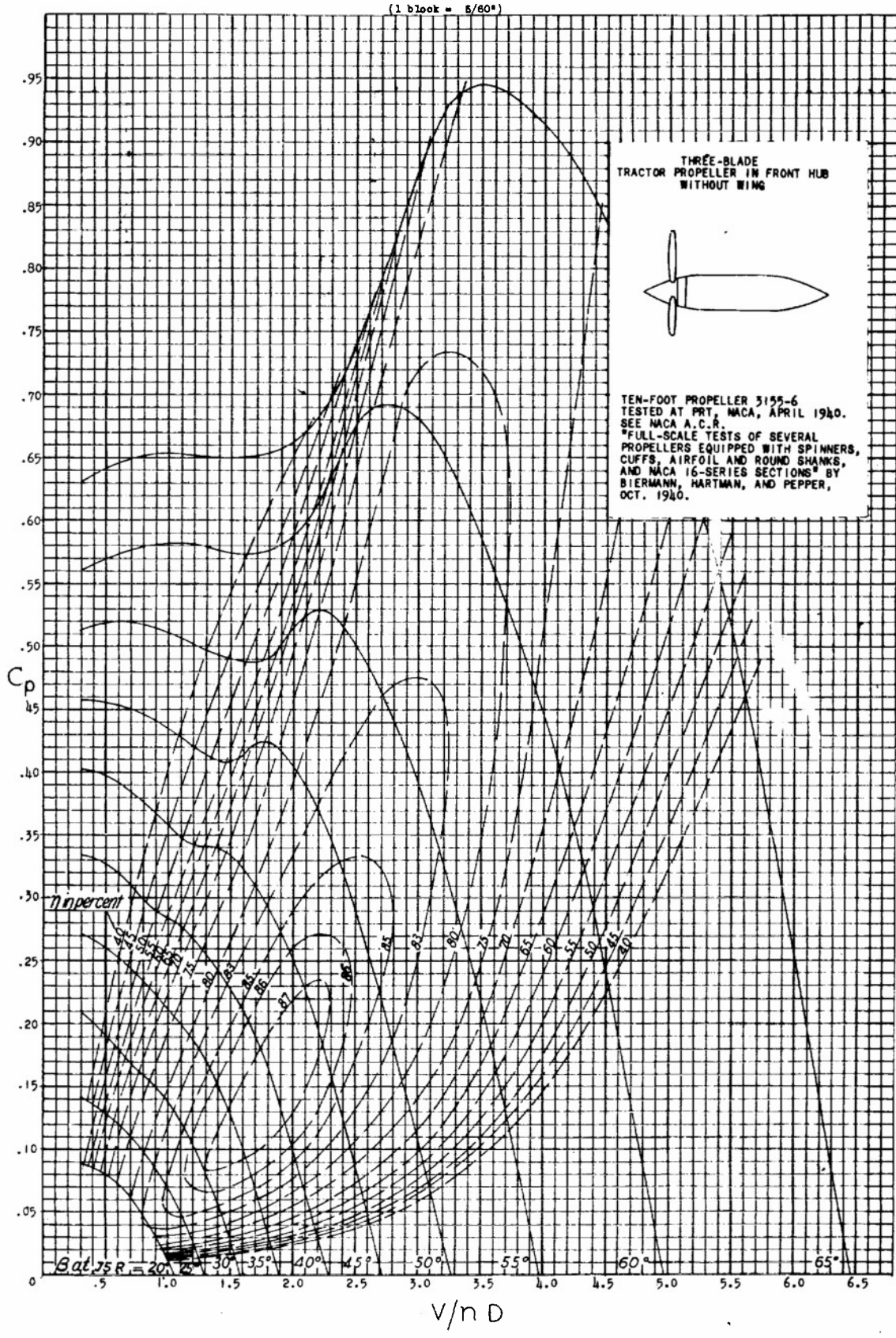


(1 block = 5/60°)



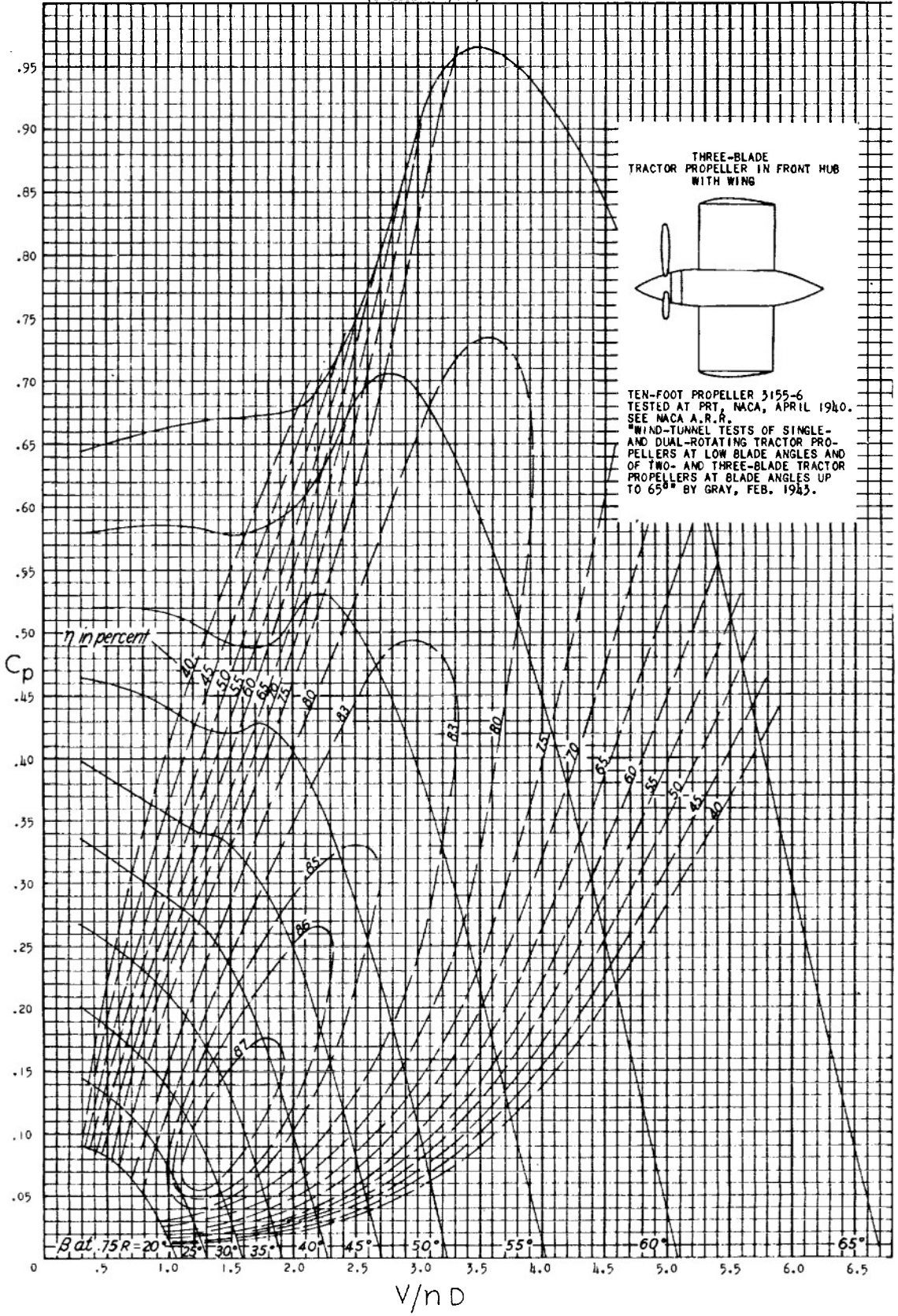
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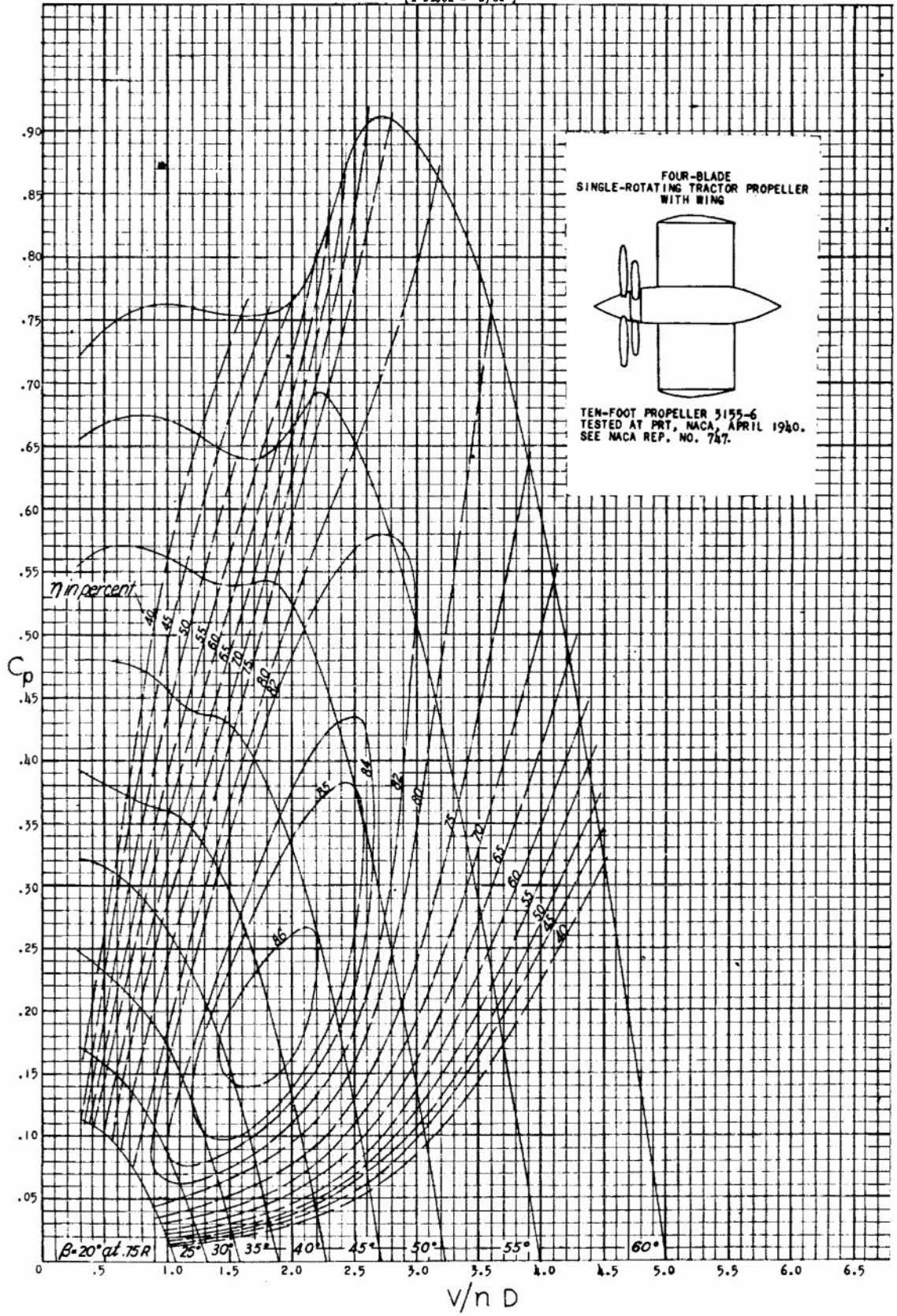
(1 block = 5/80°)

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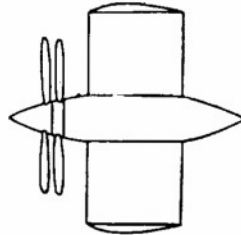
(1 block = 5/80°)

982-7

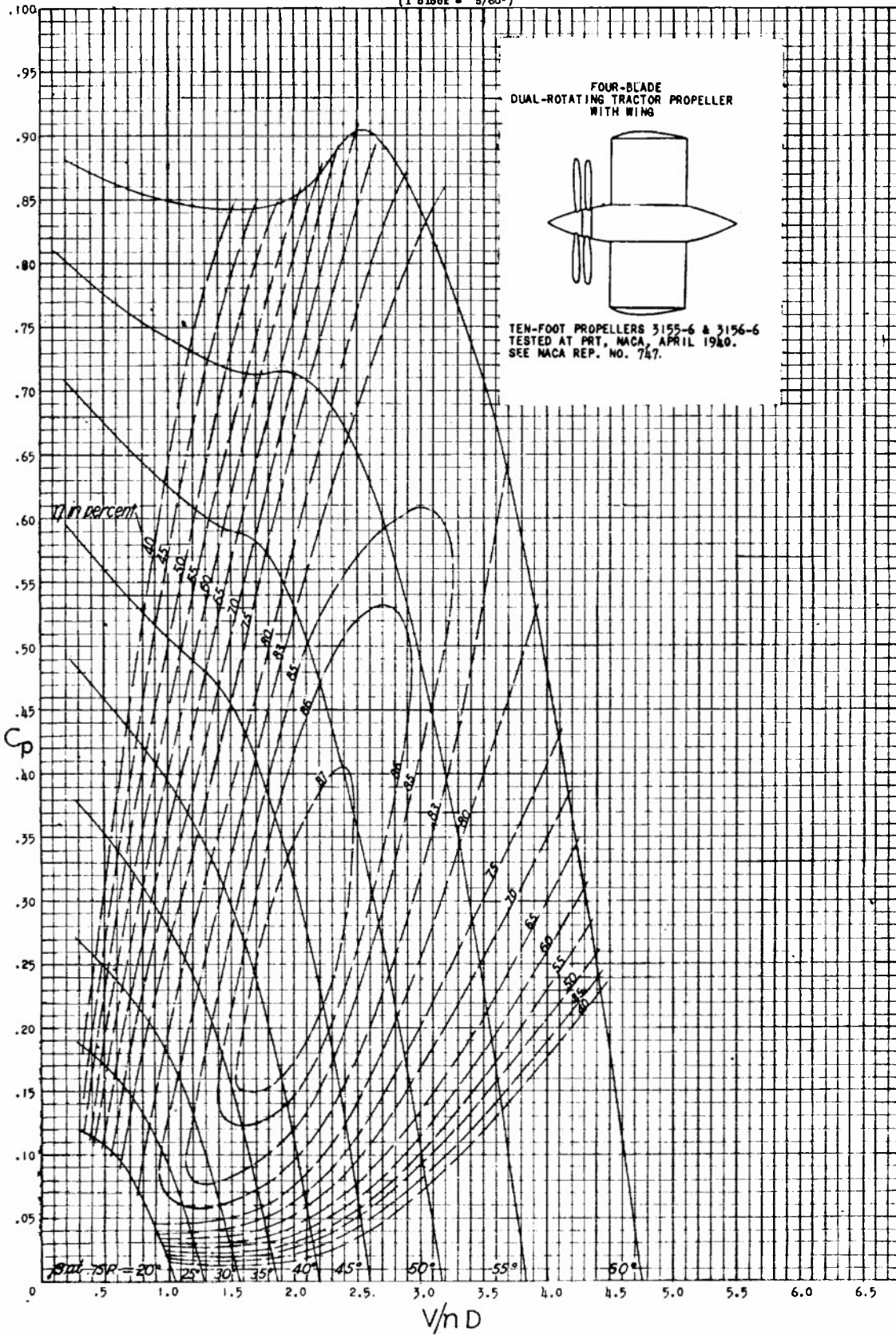


(1 block = 5/60°)

FOUR-BLADE
DUAL-ROTATING TRACTOR PROPELLER
WITH WING

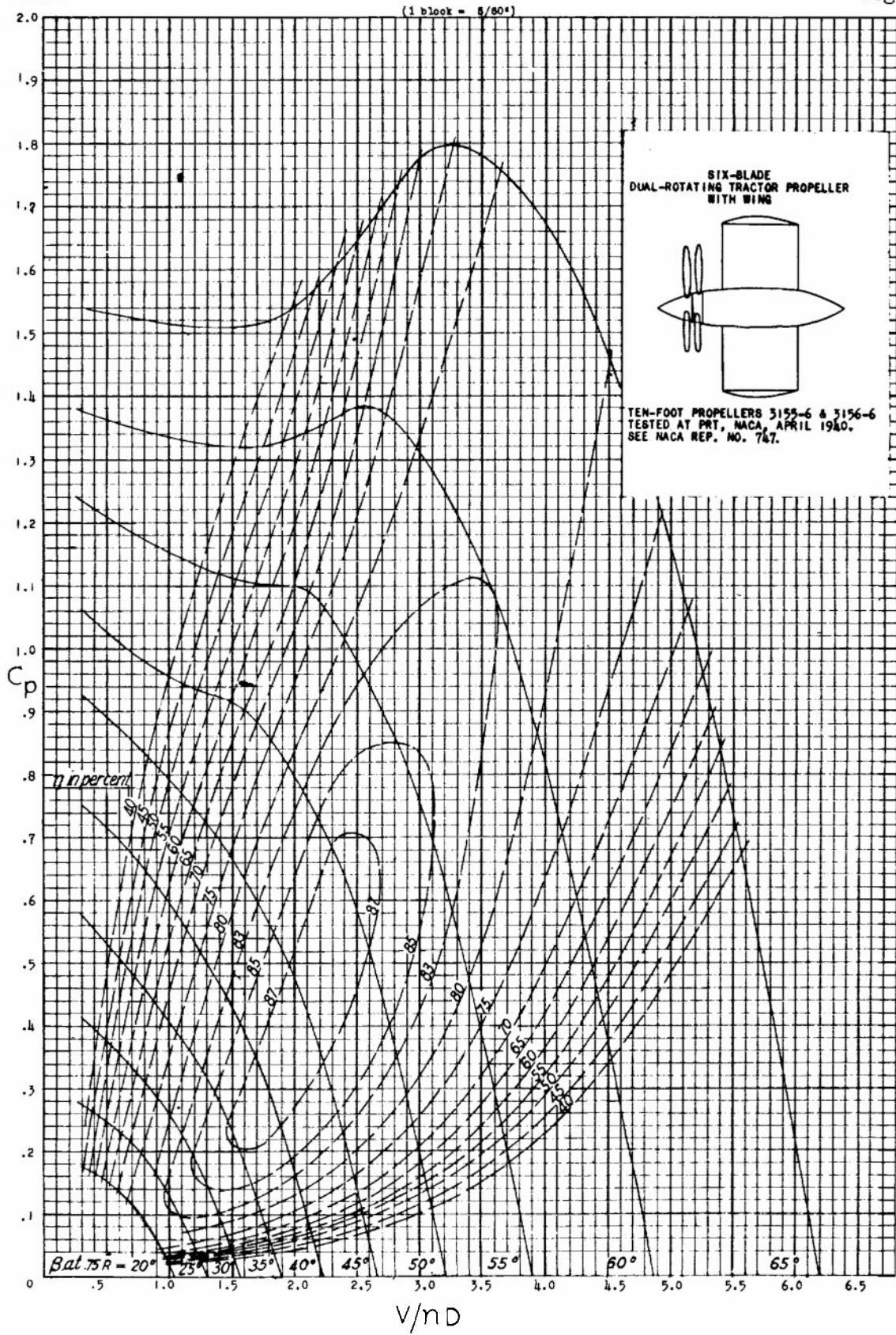


TEN-FOOT PROPELLERS 3155-6 & 3156-6
TESTED AT PRT, NACA, APRIL 1940.
SEE NACA REP. NO. 747.



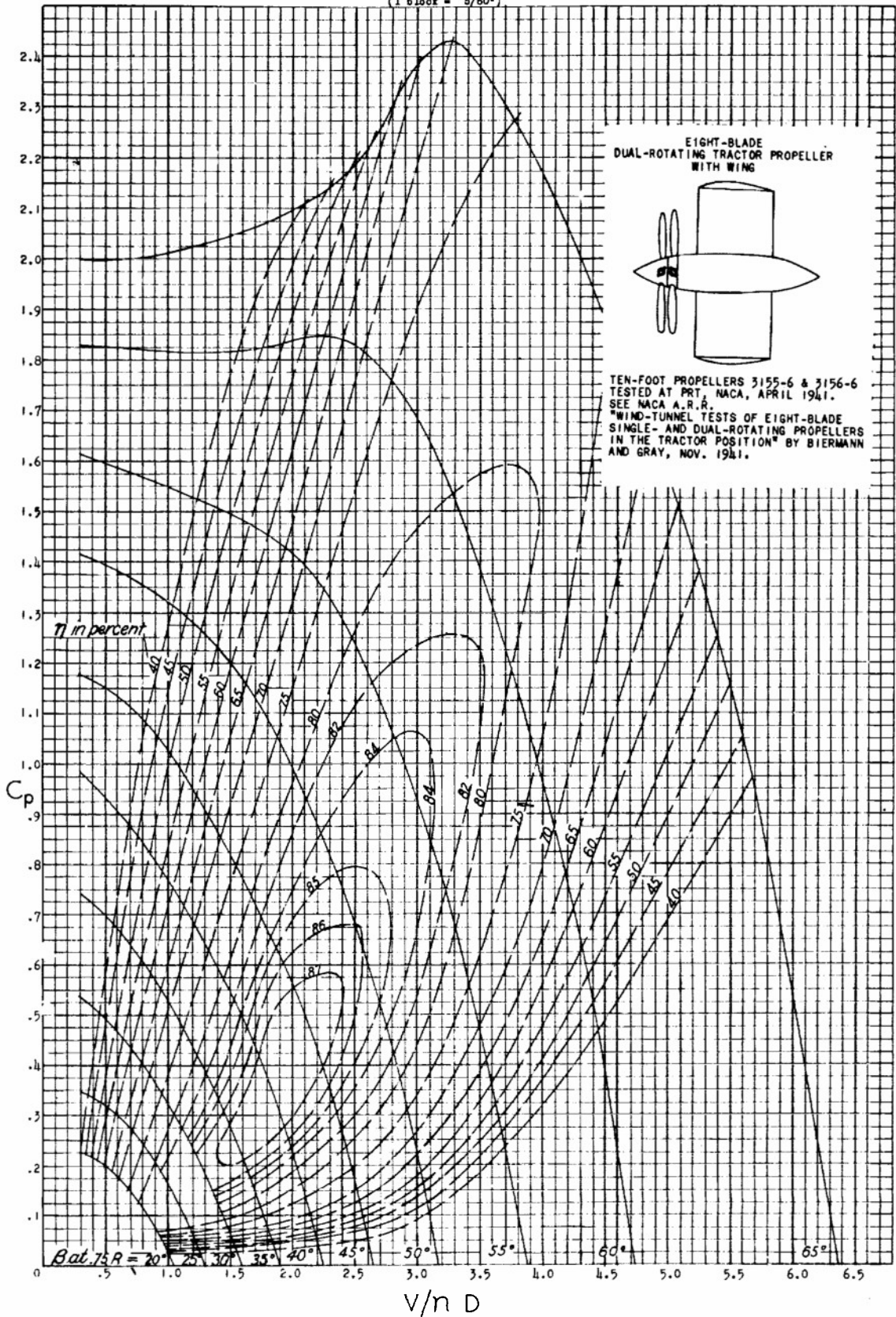
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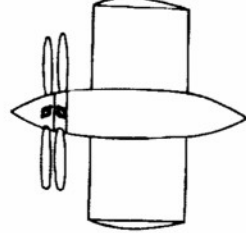


(1 block = 5/80°)

982-7



EIGHT-BLADE DUAL-ROTATING TRACTOR PROPELLER WITH WING

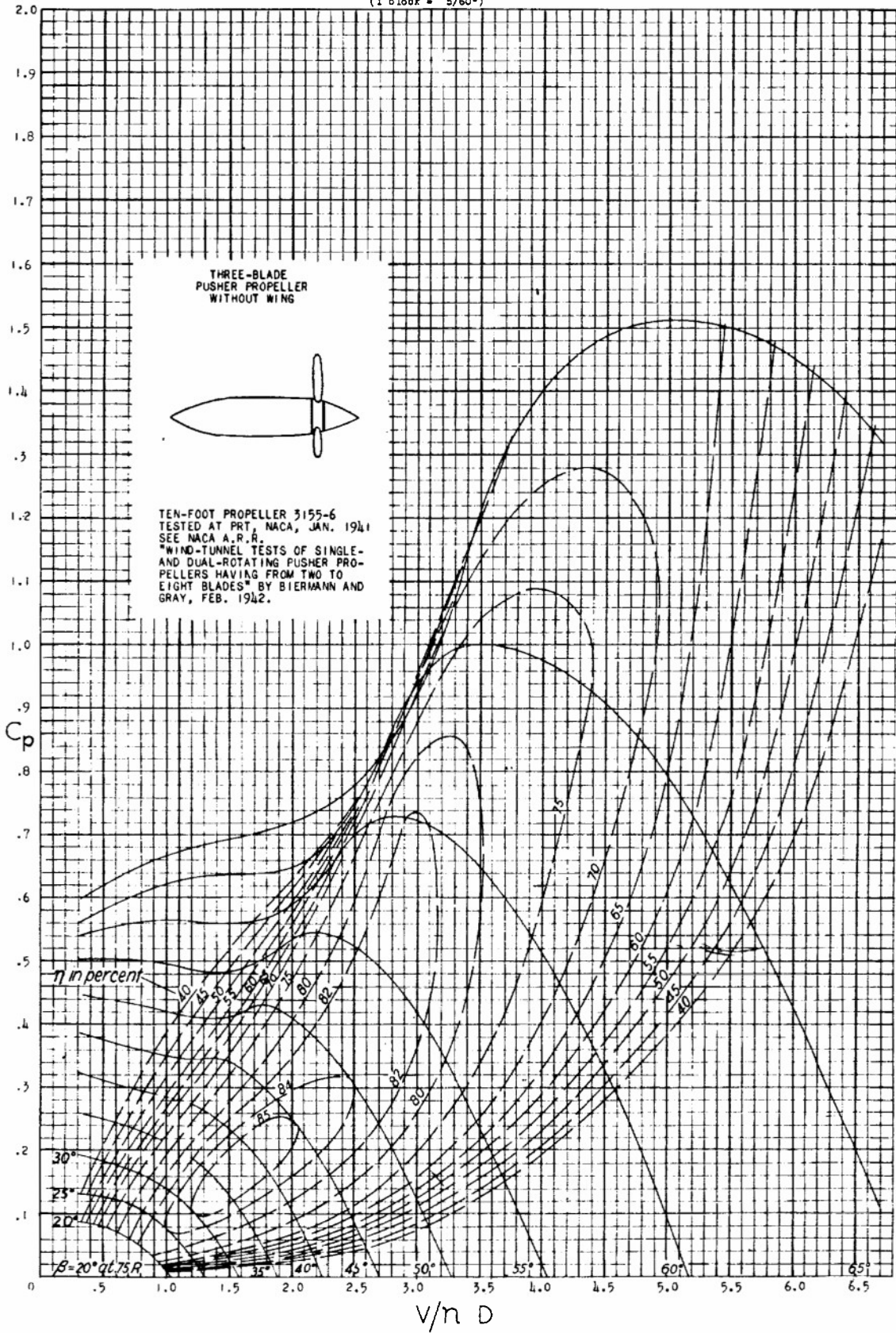


TEN-FOOT PROPELLERS 3155-6 & 3156-6 TESTED AT PRT, NACA, APRIL 1941. SEE NACA A.R.R. "WIND-TUNNEL TESTS OF EIGHT-BLADE SINGLE- AND DUAL-ROTATING PROPELLERS IN THE TRACTOR POSITION" BY BIERMANN AND GRAY, NOV. 1941.

$\beta_{at. 75R} = 20^\circ, 25^\circ, 30^\circ, 35^\circ, 40^\circ, 45^\circ, 50^\circ, 55^\circ, 60^\circ, 65^\circ$

v/nD

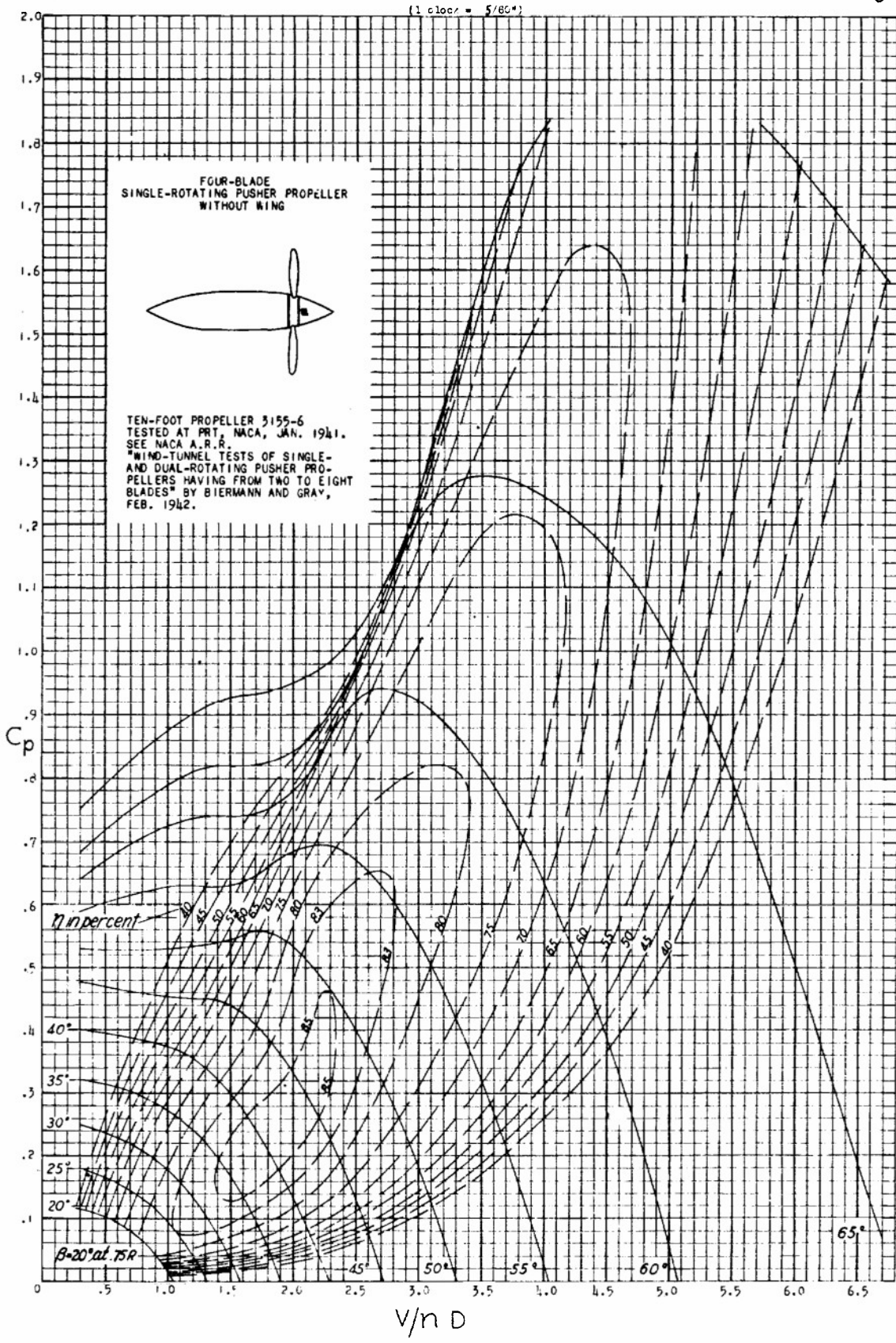
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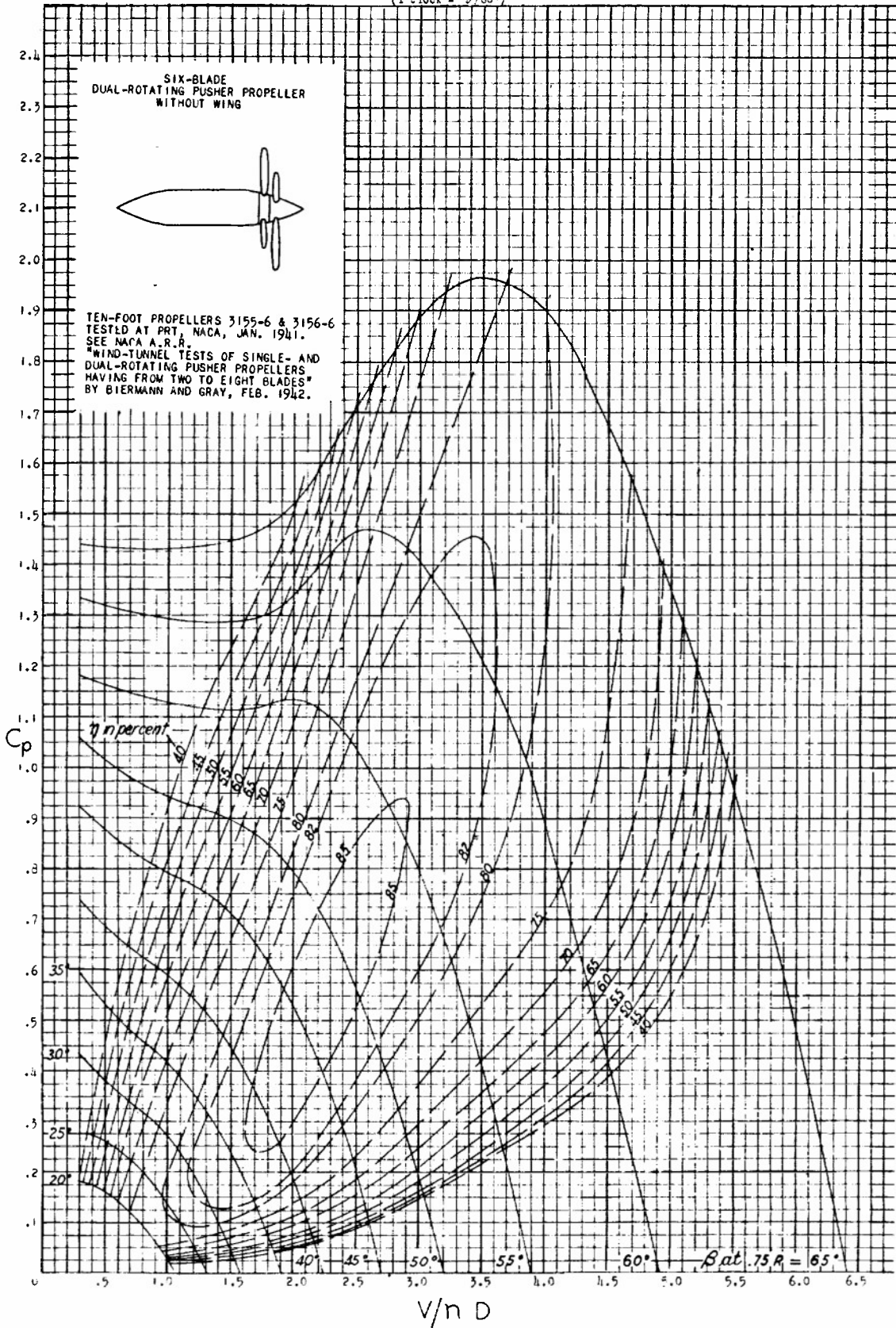
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Fig. 11



(1 clock = 5/60°)

782-7

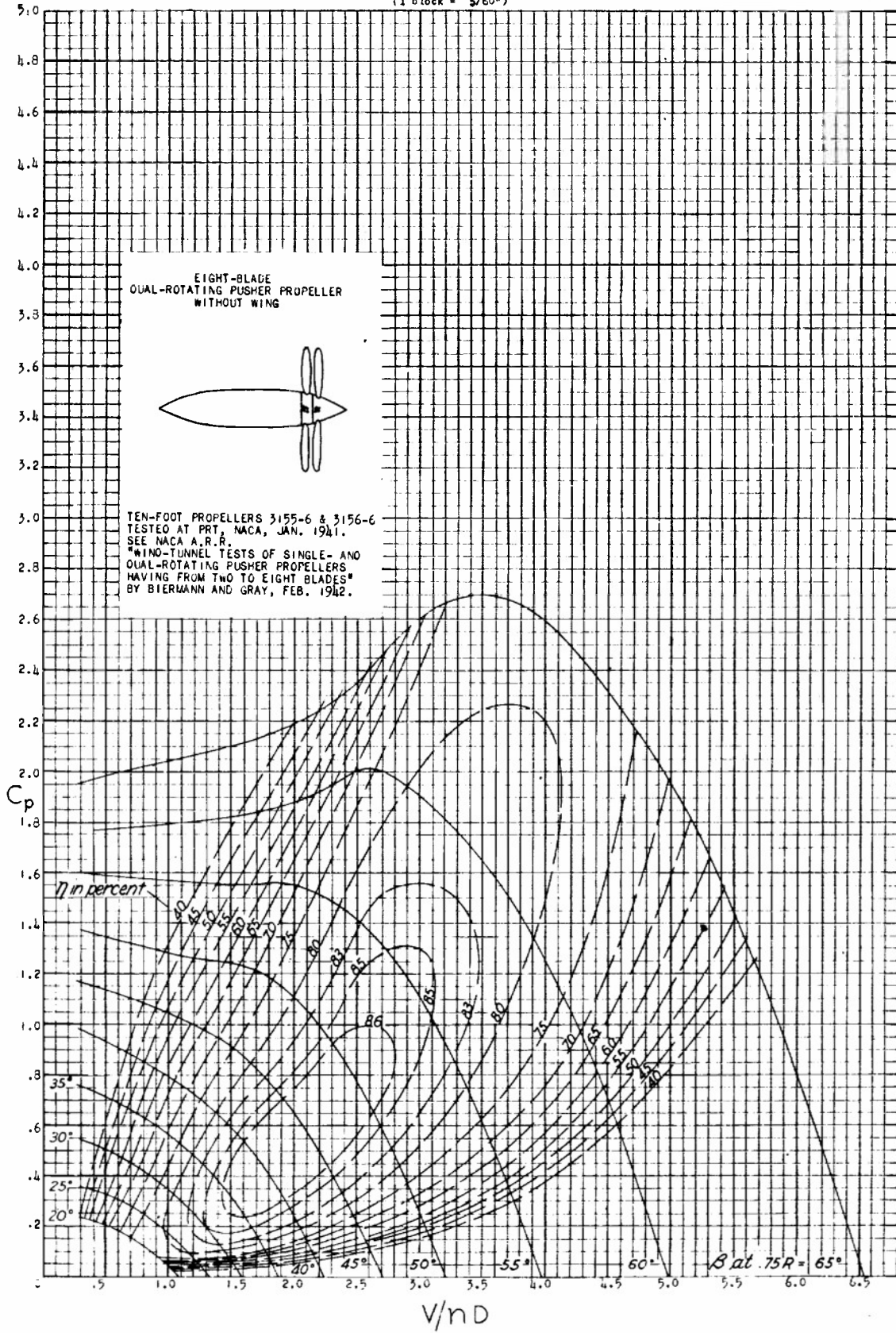


782-7

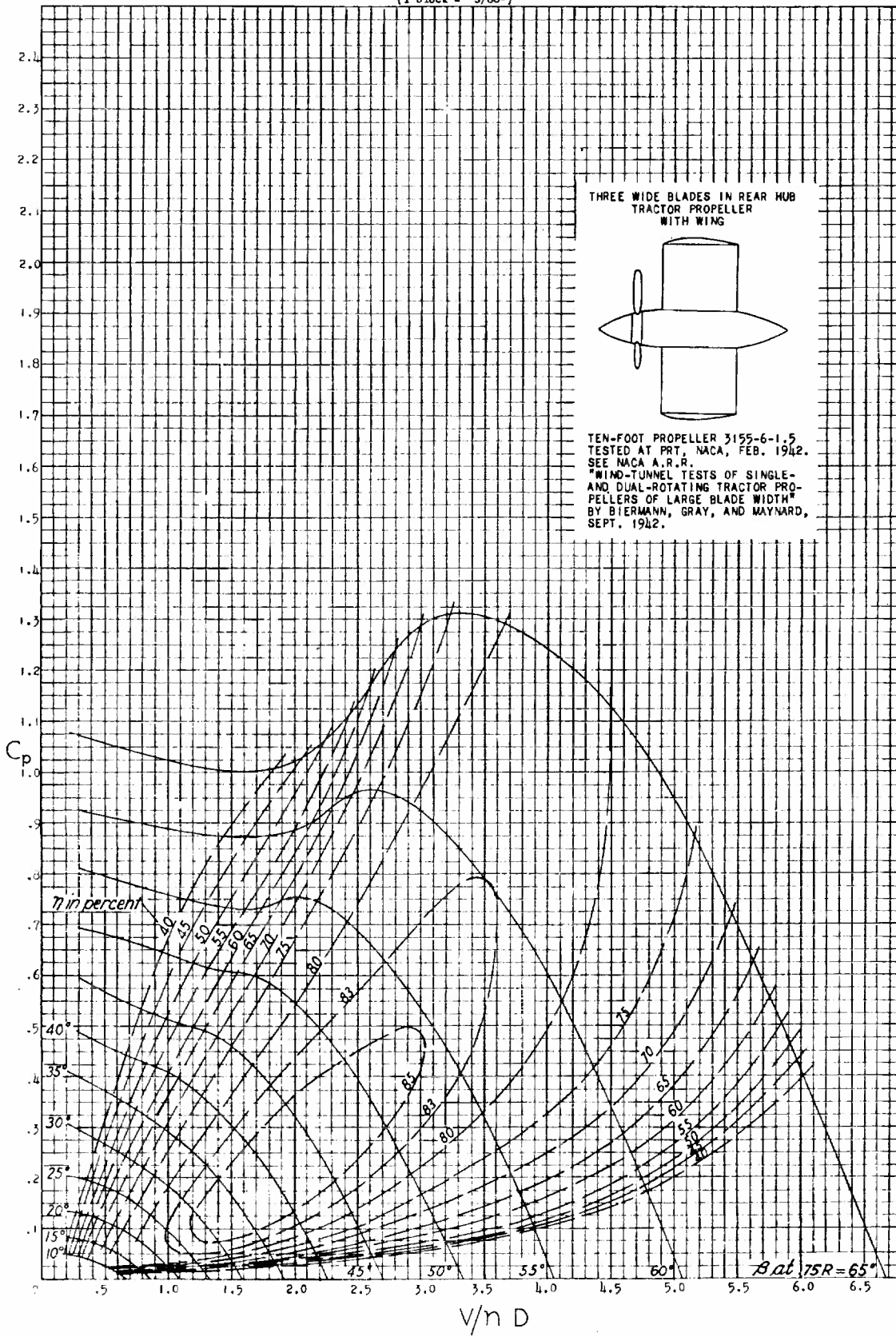
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(1 block = $5/60^\circ$)

Fig. 13



L-286

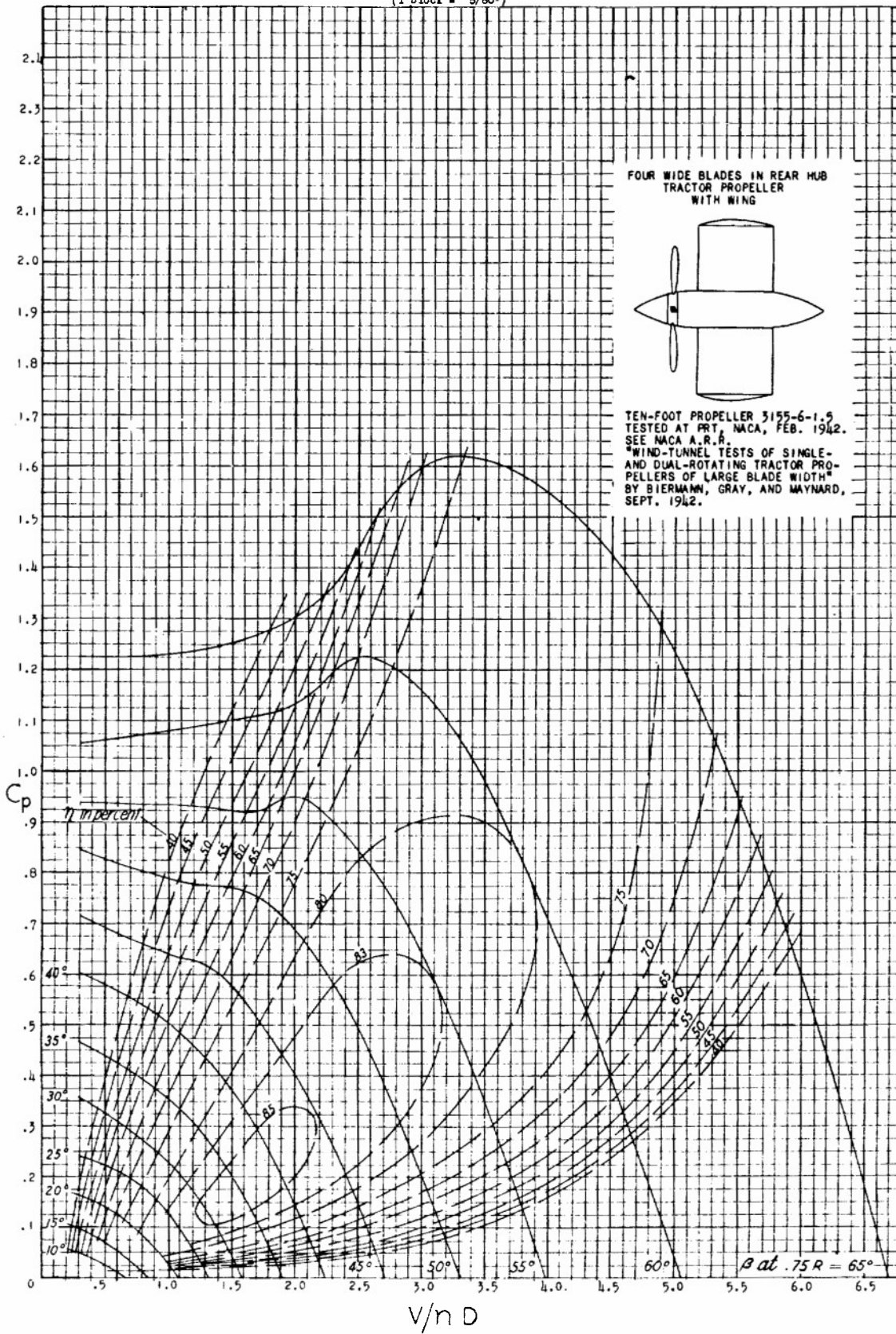


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(1 block = 5/60°)

Fig. 15

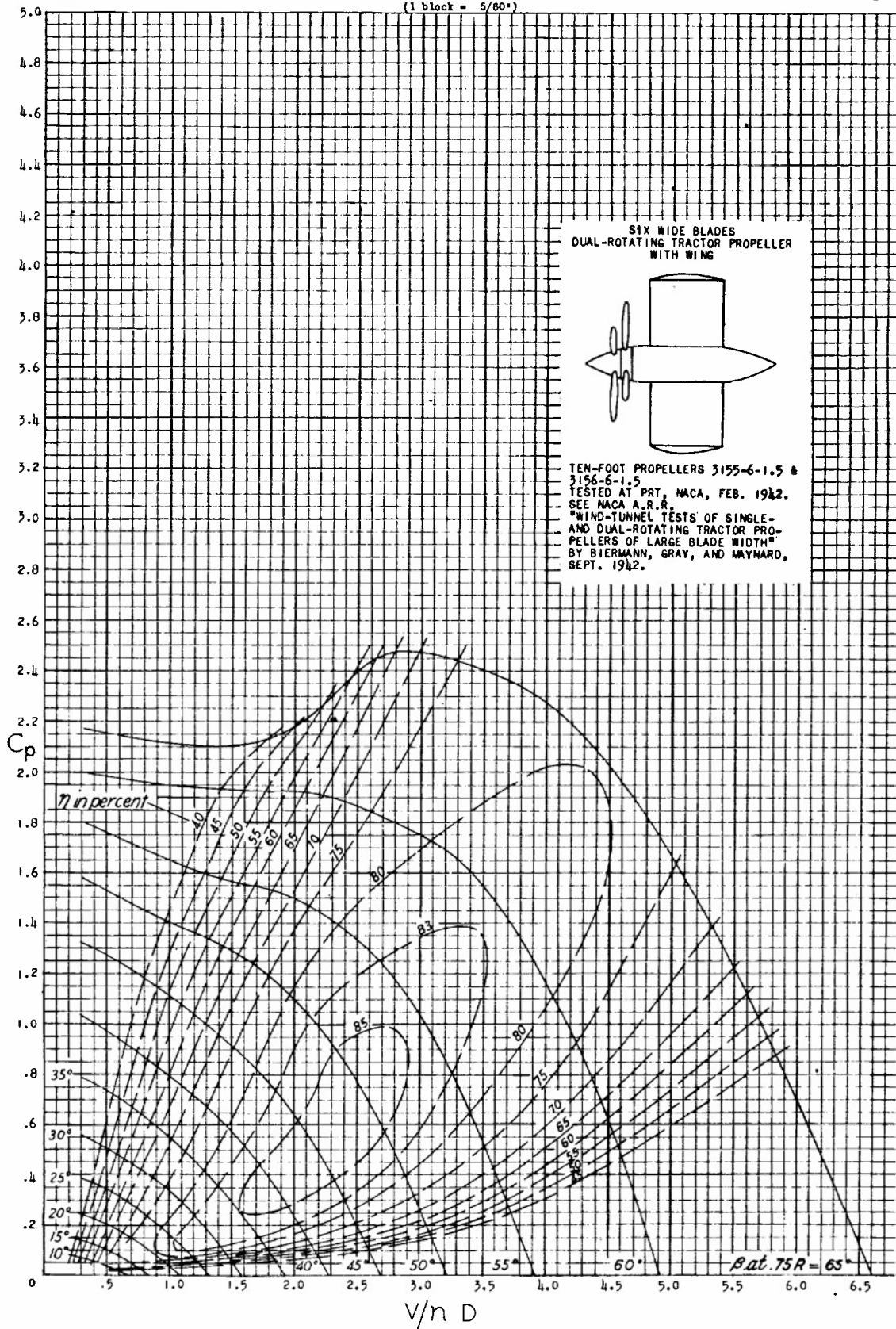


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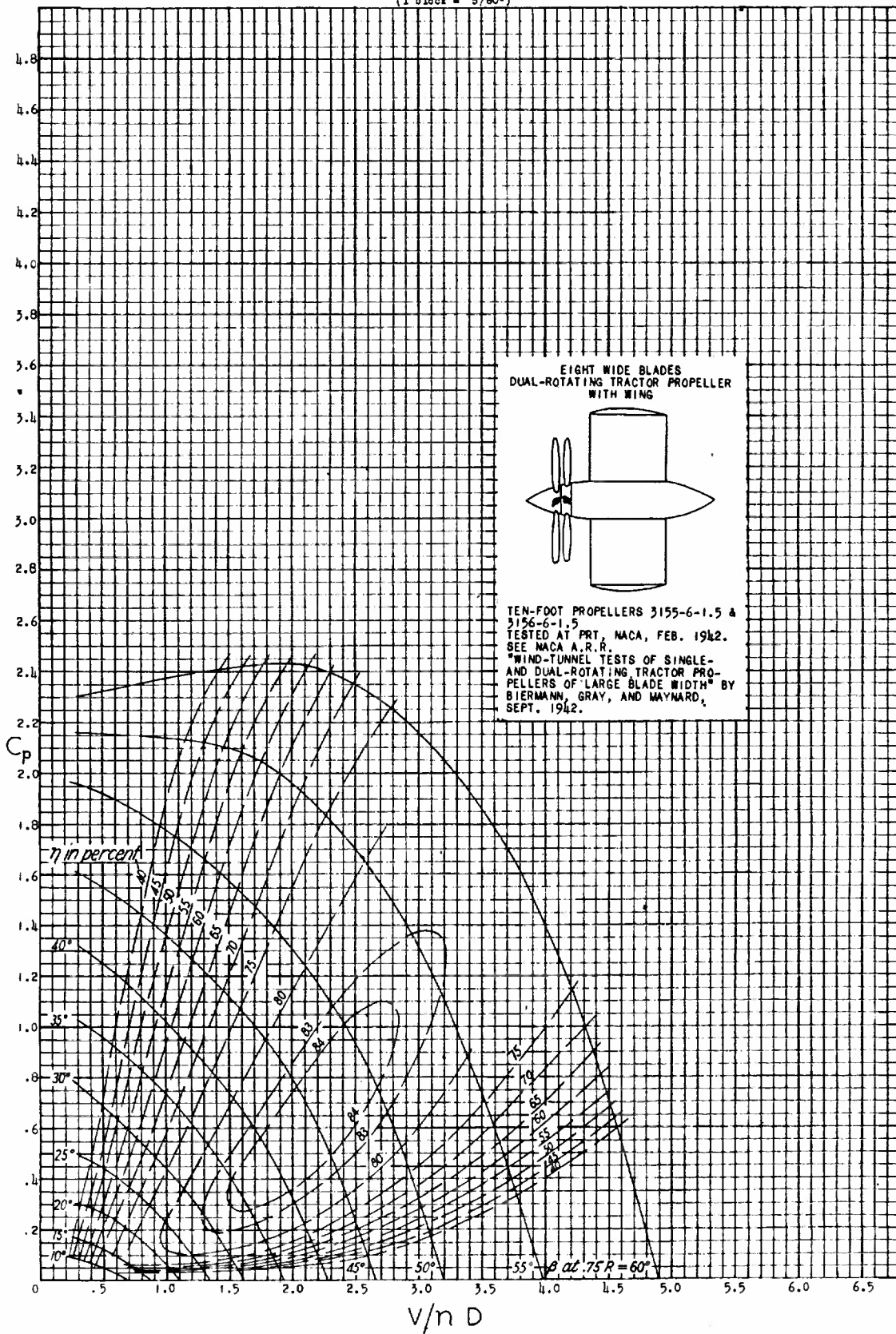
(1 block = 5/80°)

Fig. 16



4-286

(1 block = 5/80°)



FORM 10 (10 FEB 57)

Gray, W. H.
Mastrocola, N.

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SECTION: Testing (8)
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|---------|----------|--------------|--------------|--------|-------|--------|--------------------------|
| U. S. | Eng. | | Unclass. | Sep'43 | 20 | 18 | tables, graphs, drawings |

ABSTRACT

Present report has been compiled from data taken from series of fairly recent tests of full-scale propellers. Charts presented for performance estimate consist of power coefficients plotted against V/nD with lines of constant efficiency superimposed and are only for conditions considered to be useful in present day design. In preparation of plots presented, data were cross-faired and do not necessarily check exactly, with previously published data, although charts covering other conditions have been developed and are available.

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