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Approved For Release 2005/06/23 : CIA-RDP78B05171A000400030025-3

NPIC/TSC/RED-150/71
20 OCT 1971

MEMORANDUM FOR: Chief, Operations Division, Imagery Exploitation Group

THROUGH : Chief, Imagery Exploitation Group, NPIC

X1 SUBJECT : [redacted] 1540 Light Table/Zoom 240 Optics Focus and Magnification Investigation

1. In response to your memorandum NPIC/IEG/OD/TPB-130/71, dated 29 July 1971, this memorandum and attachments indicate the results of an extensive investigation into the 1540 Light Table/Zoom 240 Stereoscope focus and magnification problem. It has become evident that the three major components of the total system--i.e., operator, the viewing system, and light table--are all contributing to the overall problem.

2. Attachment A is a discussion and interpretation of the series of curves presented as Attachment B. Figure 3 of Attachment B is included and annotated to aid in the discussion. The reader should be able to interpret any of the curves in Attachment B with the aid of Attachment A.

3. Attachment C includes memorandum NPIC/TSC/ESD/TEB-125/71, dated 1 September 1971, and is a discussion and interpretation of that memorandum in terms of the data presented in Attachment B.

4. Attachment D is a discussion of proposals to extend the magnification range of the Zoom 240 Stereoscope system by means of new 15X wide-field eyepieces, a 3X monoscopic objective lens, and 3X stereo objective lenses.

5. Our analysis to date indicates that the depth of focus of the optical system is sufficient to allow the scanning (assuming a properly adjusted system) of imagery up to a magnification of about 30X throughout the entire 18 inch by 40 inch viewing area without the necessity of refocusing the system. Furthermore, sufficient focus adjustment is available in the Zoom 240/Mod 28 Rhomboid systems to allow viewing with fixed optics (no scanning)

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at magnifications up to 135X. These statements presuppose that viewing is accomplished in the monoscopic mode only.

6. Recent tests show that the Mod 28 Rhomboid arms attached to the Zoom 240 stereoscope do not always rotate in a plane parallel to the mounting surface of the optics, and therefore are not parallel with the viewing surfaces of the light table--this problem is inherent in the present design of the production Zoom 240's. This rotation appears sufficiently non-planar in some instances so as to prohibit scanning in stereo and even to prohibit the achievement of proper focus by the rhomboid arms except at lower magnifications. Possible causes for this condition have been identified and a solution appears feasible.

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[redacted] is presently investigating the problem and is expected to propose a modification during October. Upon correction of this problem, the statements in paragraph 5 above will apply to stereo viewing as well as monoscopic viewing. Note that any viewing in a scanning mode above 30X will still present special problems, i.e., refocusing, film flatness, etc.

7. Another problem is operator failure to use the equipment properly. A significant number of the PI's apparently do not follow proper procedures for obtaining initial focus adjustments and then do not ensure that proper adjustments are maintained throughout the total period of use of the equipment. These adjustments are critical in the higher magnification ranges. With improper use of the focus adjustments the operator can very easily find himself at the extremes of focus (no adjustment left): this would be particularly true with the multiple focus adjustments (all interrelated) available in the proposed 3X stereo objectives. In this respect, some form of PI training in the proper use and operation of the viewing equipment is essential. However, this is an operational problem, not an equipment problem, and therefore will not be discussed further in this memorandum.

8. In some instances, the parallelism and the collimation of the viewing surfaces and optics mount have been found to be out of tolerance. However, to our knowledge, those tables brought to the attention of ESD have now been adjusted within tolerance. This problem of alignment is of substantially less importance than those described in paragraphs 6 and 7 above; however, it is a definite contributing factor. With respect to

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the parallelism of the viewing surfaces, periodic checking for parallelism will be performed by ESD/PPB personnel during regularly scheduled preventive maintenance. It is important to note that the PI himself should never attempt any adjustment of the viewing surfaces.

9. It should be further emphasized that throughout this investigation and subsequent discussion the question of film flatness has not been addressed in detail. This is a significant problem at high magnification viewing. There is currently no entirely satisfactory means available to the PI for holding the imagery sufficiently flat on the viewing surfaces of the light table above approximately 30X. All of the ring, or U shaped, hollow hold down devices presently in use allow some degree of film bulging within the confines of the device. The magnitude of the bulge is unknown, is quite variable, and has a direct impact on the ability of the system to maintain focus at higher magnifications. Cover glasses are an alternative; however, the cover glass used must be of rather substantial thickness (weight) to be effective, and this thickness could become a problem at higher magnifications because of the small working distance of the optics at these magnifications, i.e., no space. Furthermore, the use of cover glasses degrades the image, introduces optical aberrations, and normally precludes scanning. It is obvious that vibration will become an increasing problem with increasing magnification because it enlarges the apparent displacement.

10. Our investigation indicates that it should be possible to develop optics that will extend the magnification of the present system to 120X. However, although sufficient focus range should be available to accomodate the expected variations in position of the viewing surfaces, scanning over an appreciable area will not be possible at the higher magnifications without repeated refocusing. Furthermore, the eye relief of the 15X eyepiece is expected to be 13mm rather than the recommended 20mm minimum. This may cause some discomfort for the operator wearing eyeglasses. As a comparison, the eye relief in the 10X eyepiece is 22mm, and for the 15X eyepiece is 16mm. Also the 3X objective lenses will present operational problems in that the mono and stereo lenses are by no means parfocal (they focus at different distances from the table surface). Indeed, it will be necessary to remove the stereo objective lenses

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when using the mono lens, and the resulting clearance ... the rhomboid arms and the viewing surface is expected ... only 2mm (0.078 inch). Such a small clearance may c... problems with film curl and hold-down devices. Addi... focusing and resolution problems are pointed out in ... 9.

11. It is apparent that the Zoom 240 is being ... to its limits of capability and the extension will r... equipment that is useful but not completely satisfac... three major areas of concern should be emphasized: (1) ...tion, (2) defocusing (when scanning), and (3) high ma... viewing. These problems are difficult to completely ... because they are basically interrelated.

a. Vibration causes a blurring of the ima... and a loss of resolution as observed through the optics. The problem is being studied by Tyne ... Towards this end, a new (stiffer) beam has been designed and soon will be put under test and evaluation; this should minimize the problem. ... problem can be partially solved, on an interim ... by clamping the current beam--thereby shortening its effective length. However, this restricts ... X travel of the stereoscope which may be undesir... Investigative work is continuing in this area.

b. Some defocus problems have occurred when the microstereoscope is moved over the total imagery format at higher magnifications. Proper focus, and its retention, is a function of (1) proper focusing procedures by the operator, (2) proper alignment of the table and microstereoscope components, and (3) the inherent depth of focus of the objective lens--this decreases as magnification increases. Solution of this problem lies in reducing the individual contributing sources of error to a minimum. TSD has already taken care of those problems which are correctible through alignment, while TED is investigating some minor engineering modifications to the Zoom 240/Mod 28 Rhomboids viewing system and to the 1540 Microscope mount.

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c. The high quality of the "9" imagery and the newness of the detail observed have combined to lead the PI's to view the imagery at magnifications which were never anticipated; i.e., 15X to 120X vice 7X to 60X (with most viewing to be done below 30X magnification). The higher ranges were never anticipated in the design of the 1540. It is doubtful that they should be.

12. At this point, it is essential to reemphasize that these problems, along with other factors (such as film flatness), are highly interrelated. If these higher magnification ranges are, in fact, desirable, then the optical viewing system and the light table must be treated as a total system and designed in unison for the best overall compromise. Vibration, depth-of-focus, illumination intensity, film flatness, field of view, eye relief, all come in to play and make the problem more difficult as optical magnification is increased. Some recently completed [redacted] work has given us new insight into the part the eye plays in this problem--it is an inherent part of the total optical system. Other parametric studies will determine the optical characteristics required in such an optimized viewing system. It is predictable that certain of these factors can be taken care of by modifications to existing equipment; however, further emphasis on the upper magnification range will require the Center's giving serious consideration to a second generation viewing system or a studied move from roll to cut film for certain critical applications. 25X

[redacted] 25X

Chief, Research & Engineering Division,
NPIC/TSC

/s/

X1 CONCUR: [redacted] 20 OCT 1971

Chief, Engineering Support Division, NPIC/TSC — Date

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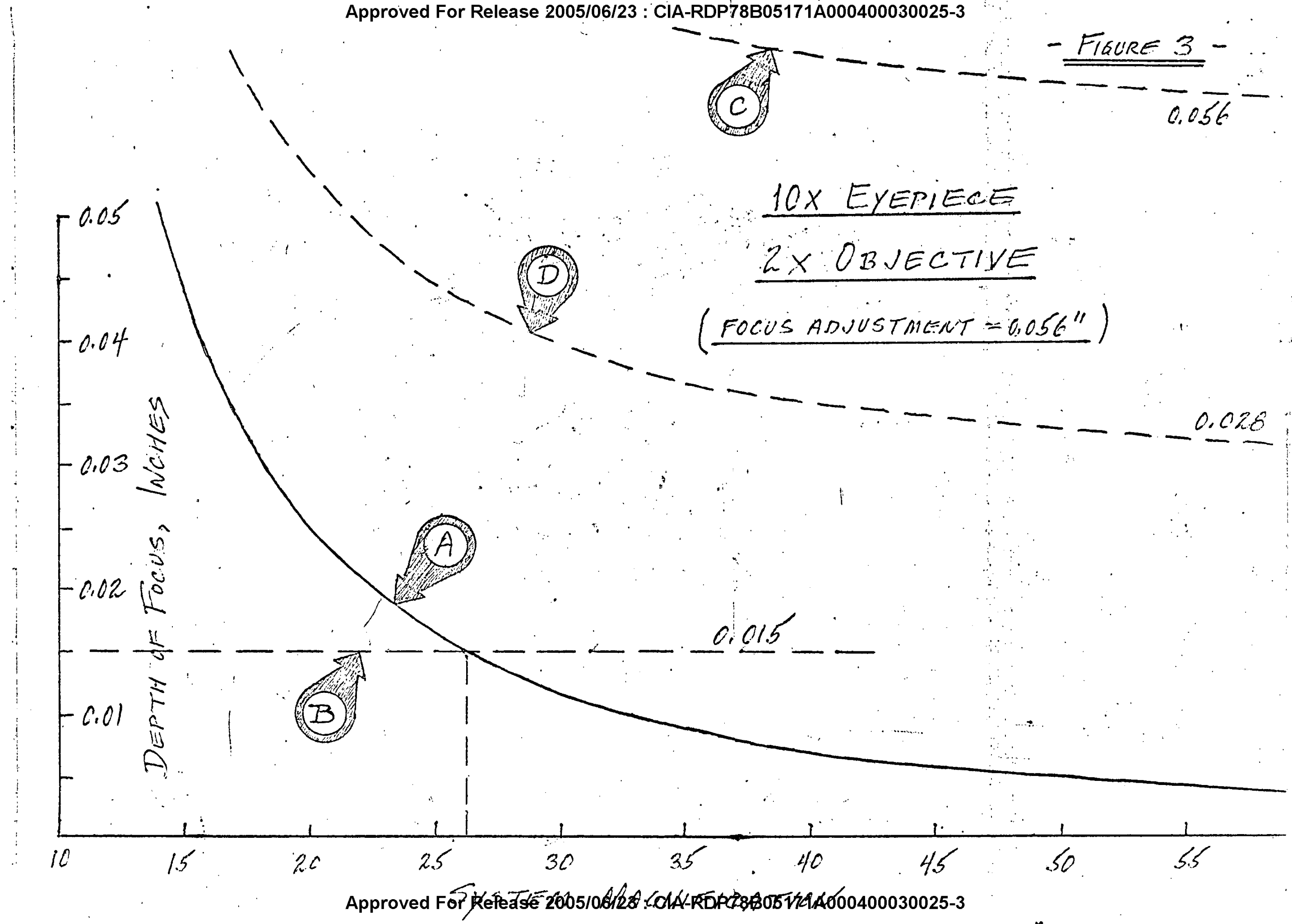
Discussion of Depth of Focus Curves

Attachment A



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The curve labeled "A" is a plot of the equation

$$DF = \left[\frac{\sqrt{N^2 - (NA)^2}}{(NA)^2} \right] \lambda + \frac{250}{M^2}$$

where,

DF = depth of focus, mm

N = refractive index of the medium in the object space

(NA) = numerical aperture of the objective lens

λ = wavelength of light

M = total magnification.

The medium in the object space in this instance is air and N, therefore, is equal to one. The wavelength of light, λ, is taken as 5.6×10^{-4} mm. The numerical aperture of an objective lens is fixed by the design of that lens, and, for the 2X objectives, is equal to 0.172. The first term of the equation for depth of focus is, therefore, a constant which may be identified as C_1. The second term of the equation includes the constant 250 which may be identified as C_2. This number is the normal viewing distance, in millimeters, of the average eye.

The equation for depth of focus may therefore be written

$$DF = C_1 + \frac{C_2}{M^2}$$

which states that the depth of focus of a system of optics and observer is the sum of a fixed amount C_1, determined by the design of the objective lens, plus an additional amount due to the fact that the eye is capable of a certain amount of accommodation. The capability of the eye to accommodate is an inverse function of the square of the total magnification.

The line labeled "B" is drawn at a depth of focus of 0.015 inch, and is equal to the amount allowed by specification that the viewing surfaces of the light table may be out of parallel with each other and with the mounting surface of the optics carriage. The intersection of curve "A" and line "B" indicates that at a total magnification of about 26X the depth of focus is sufficient to accommodate the maximum that the viewing surfaces are allowed to be out of parallel. Up to at least this magnification the system is capable of scanning throughout the viewing surfaces of the light table without refocusing. Experience indicates that it is possible to adjust the viewing surfaces parallel with each other, and with the ring mount, well within the 0.015 inch allowed and the system is capable of scanning without refocus at any magnification up to about 30X.

Each rhomboid arm incorporates an individual focus adjustment. In the case of the 2X objectives this total adjustment amounts to 0.056 inch and is drawn as the curve labeled "C". It should be recognized that this curve is not strictly related to depth of focus but is an additional range of focus over and above the depth of focus that is available to the operator to compensate for differences in the position of the film plane relative to the optics. If one of the rhomboid focus adjustments is left at its mid-point and the other rhomboid is adjusted from mid-point to a limit, the available focus adjustment amounts to 0.028 inch. This has been drawn as the curve labeled "D".

An interpretation of this illustration indicates that it should be possible to scan imagery by moving the optics anywhere within the 15 inch by 40 inch format of the table up to a magnification of 25X to 30X. Furthermore, the fact that curves "C" and "D" do not intersect curve "B" indicates that the range of available focus of the combination of 10X eyepieces and 2X objectives is more than adequate to compensate for anomalies in the system of 0.015 inch throughout the range of magnifications of 14X to 60X. Above 25X to 30X magnification the system will require refocusing as the optics are moved relative to the surfaces of the table.

The 0.015 inch dimension refers only, of course, to the maximum that the viewing surfaces of the table are allowed to be out of parallel with each other and with the optics ring mount. The curves do not address curvature of the imagery or the fact that the rhomboids may not move in a plane parallel to the table viewing surfaces when rotated from one viewing position to another. The effect of film curvature has not been investigated. The problem of rhomboid positioning will be discussed in Attachment C.

Depth of Focus Curves

Attachment B

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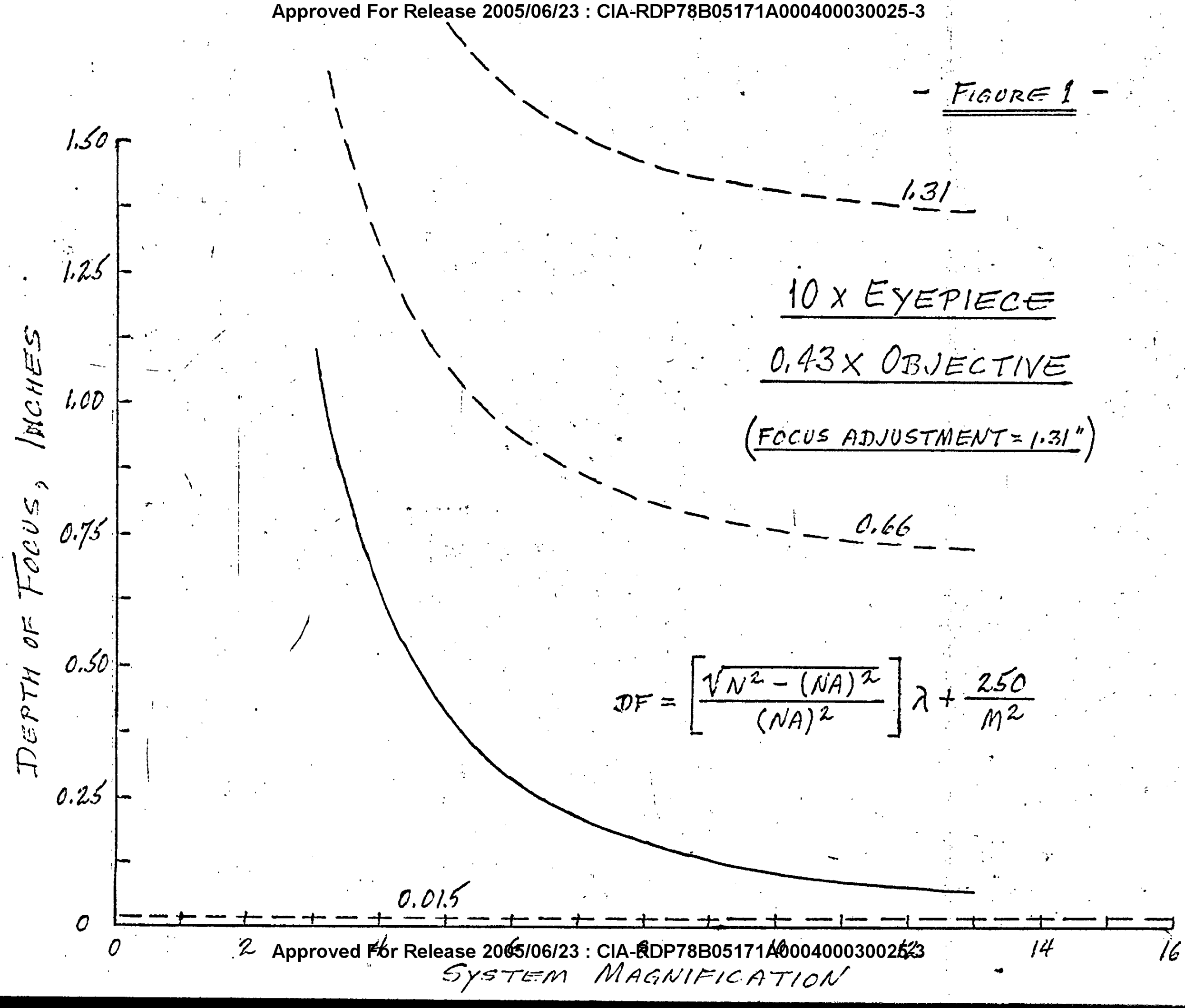
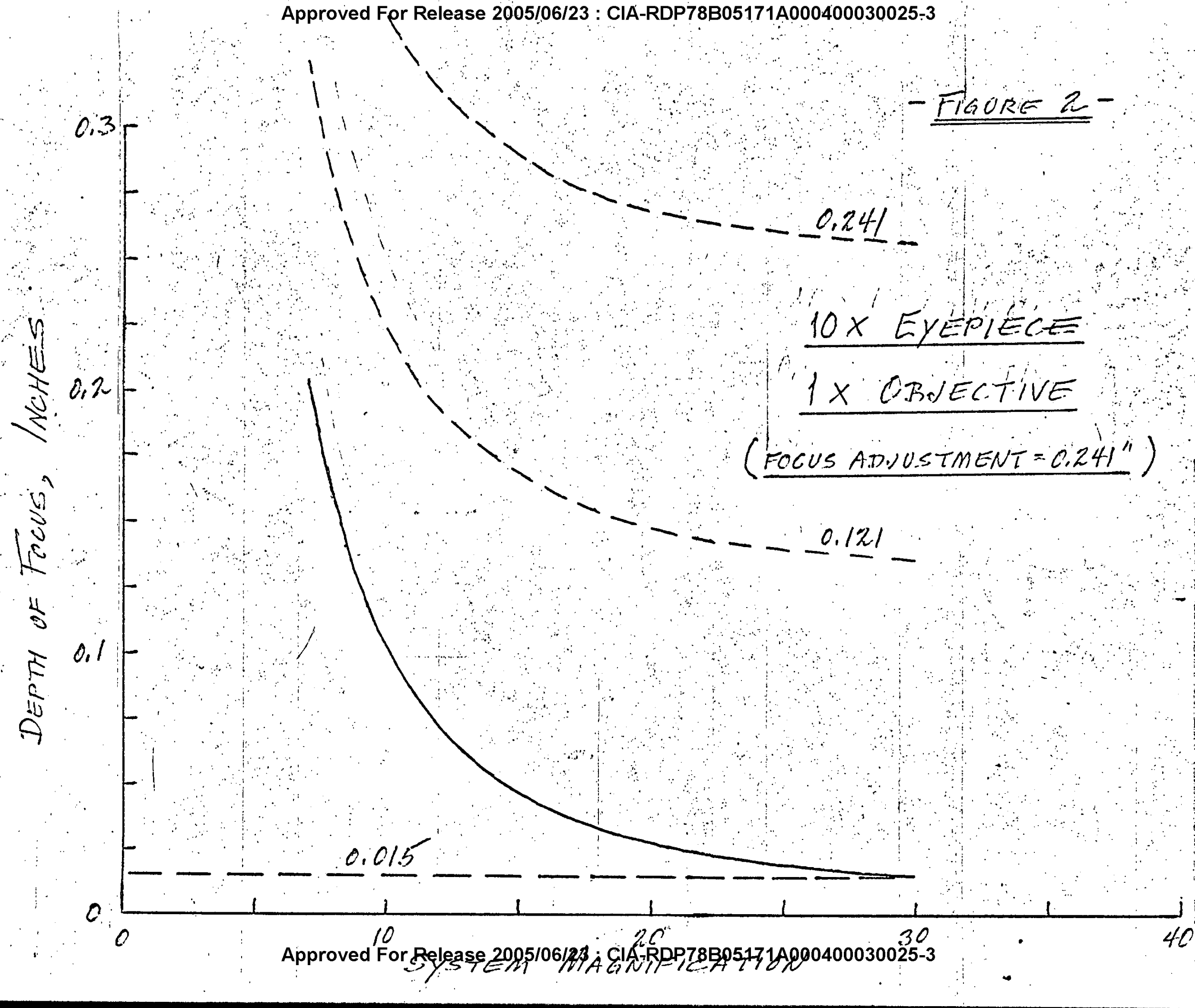
- FIGURE 1 -


1.50
1.25
1.00
0.75
0.50
0.25
0
DEPTH OF FOCUS, INCHES
0
2
4
6
8
10
12
14
16
SYSTEM MAGNIFICATION
1.31
0.66
0.015
10 x EYEPIECE
0.43 x OBJECTIVE
(FOCUS ADJUSTMENT = 1.31")
DF = [√(N² − (NA)²) / (NA)²] λ + 250/M²


- FIGURE 2 -
0.3
0.2
0.1
0
DEPTH OF FOCUS, INCHES
0.241
10 X EYEPIECE
1 X OBJECTIVE
(FOCUS ADJUSTMENT = 0.241")
0.121
0.015
0
10
20
30
40
SYSTEM MAGNIFICATION

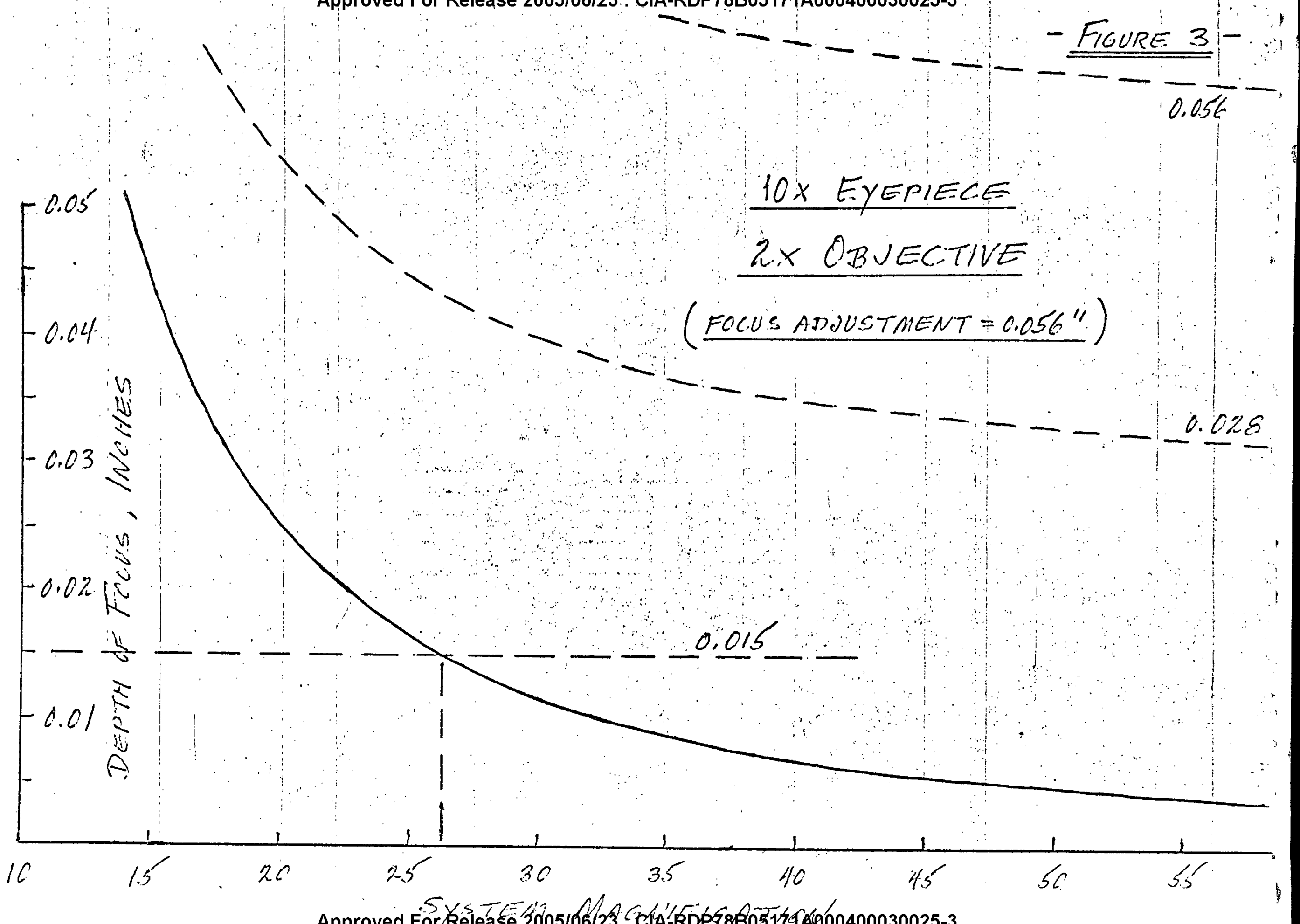
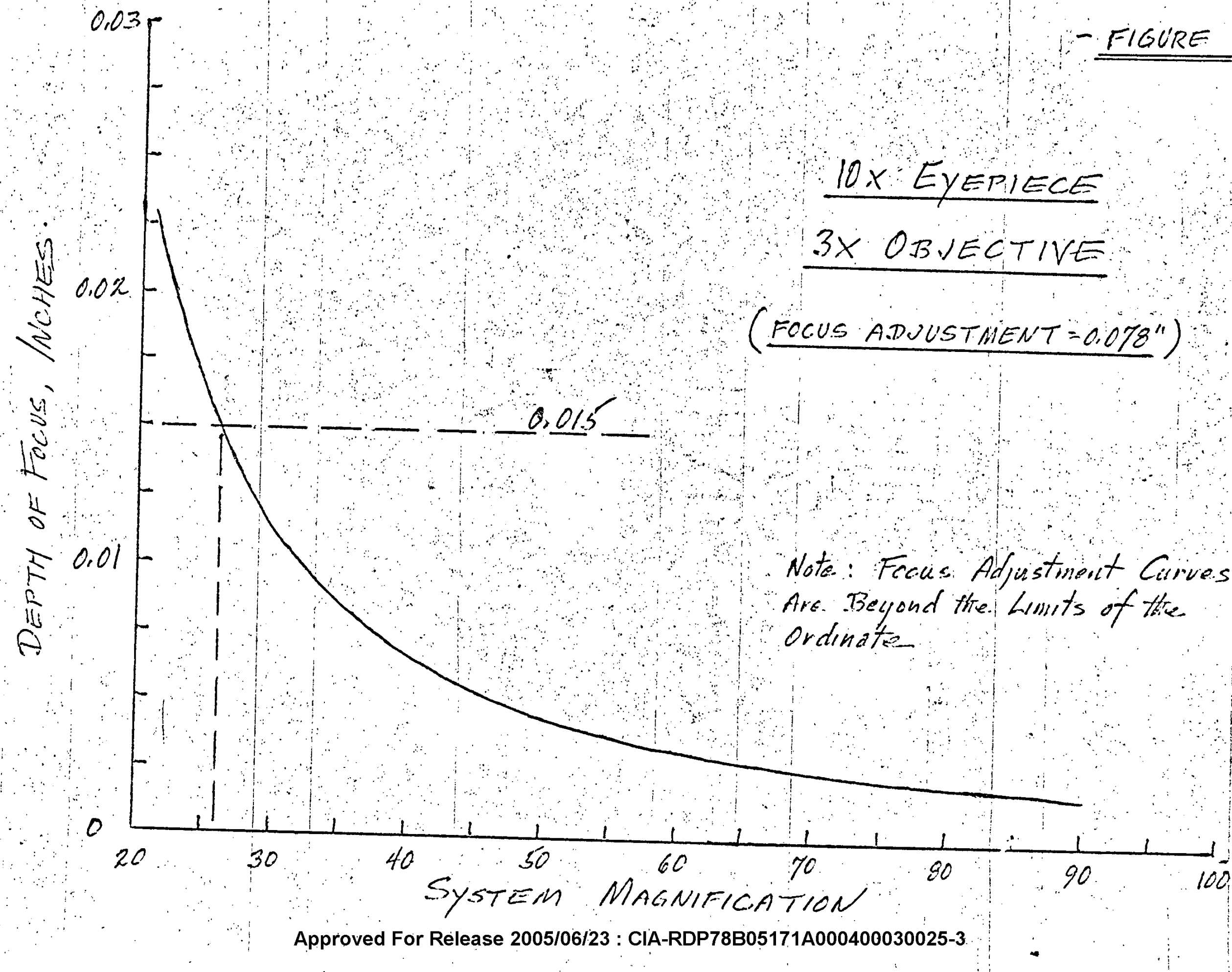
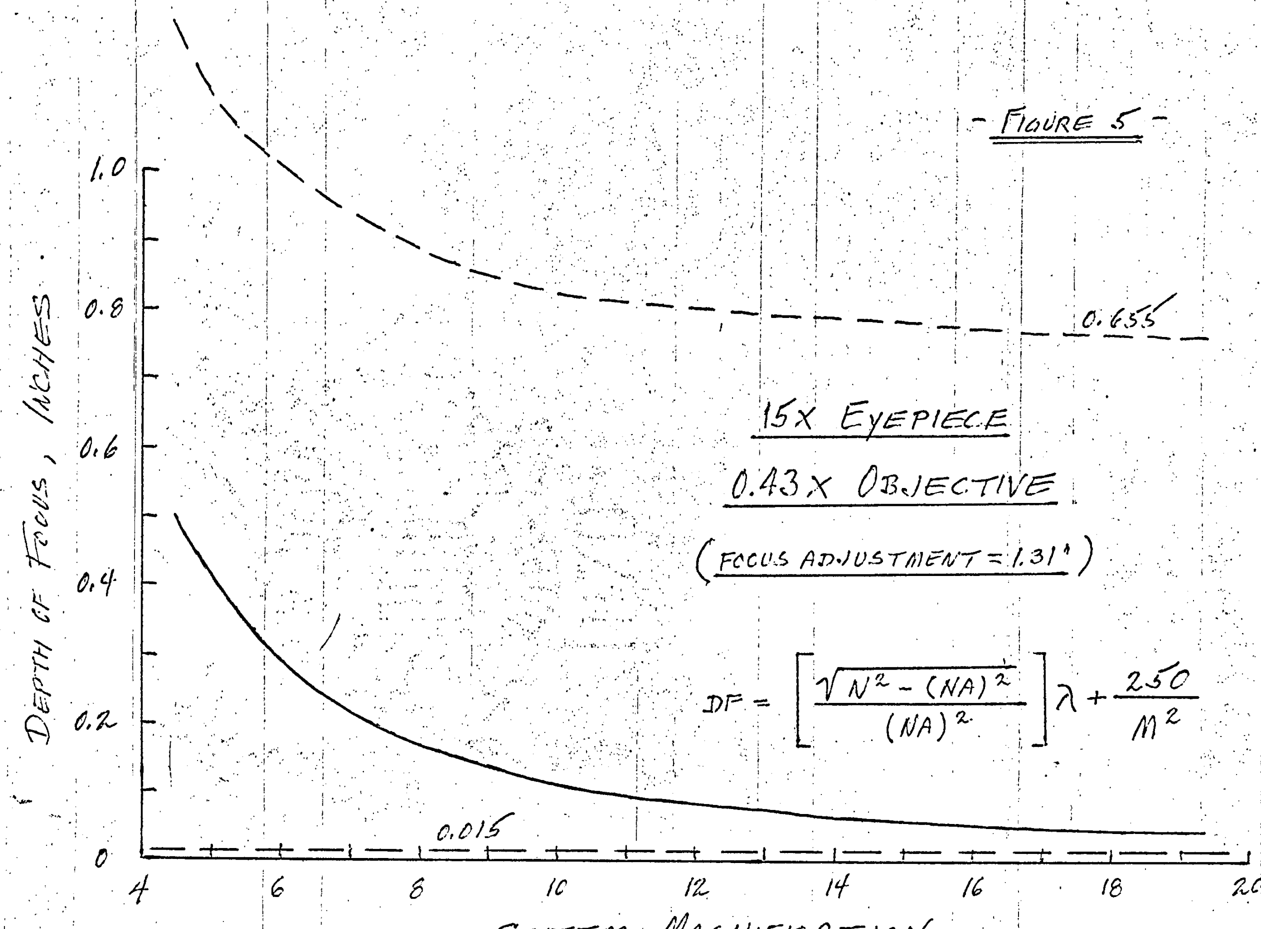


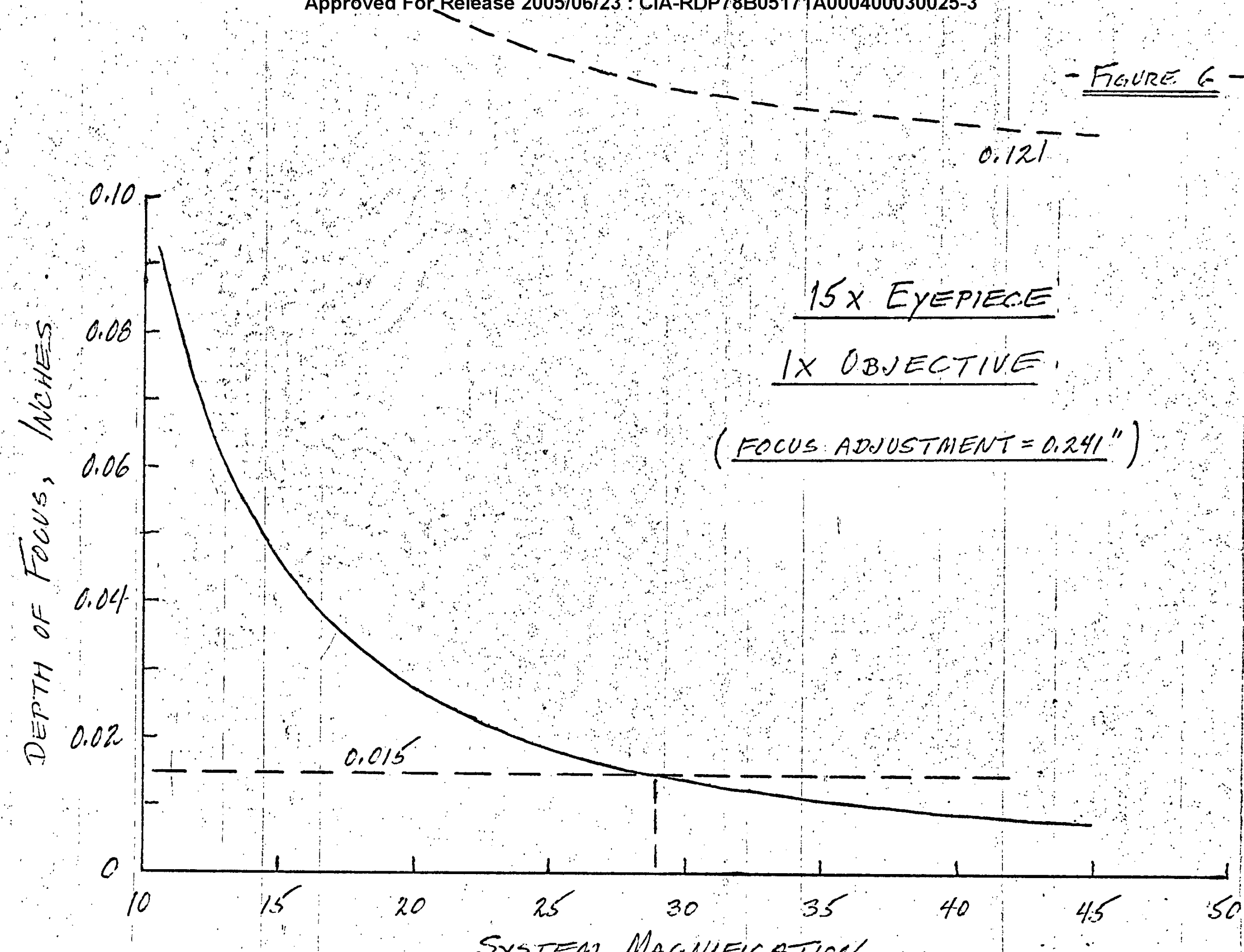
FIGURE 3
0.056
10x EYEPIECE
2x OBJECTIVE
(FOCUS ADJUSTMENT = 0.056")
0.028
0.015
0.05
0.04
0.03
0.02
0.01
DEPTH OF FOCUS, INCHES
10
15
20
25
30
35
40
45
50
55
SYSTEM MAGNIFICATION

- FIGURE 4 -


10x EYEPIECE
3x OBJECTIVE
(FOCUS ADJUSTMENT = 0.078")
0.015
Note: Focus Adjustment Curves Are Beyond the Limits of the Ordinate
DEPTH OF FOCUS, INCHES
0.03
0.02
0.01
0
20
30
40
50
60
70
80
90
100
SYSTEM MAGNIFICATION


- FIGURE 5 -
15X EYEPIECE
0.43X OBJECTIVE
(FOCUS ADJUSTMENT = 1.31")
DF = [√(N² - (NA)²) / (NA)²] λ + 250/M²
0.655
0.015
DEPTH OF FOCUS, INCHES
SYSTEM MAGNIFICATION
1.0
0.8
0.6
0.4
0.2
0
4
6
8
10
12
14
16
18
20

- FIGURE 6 -



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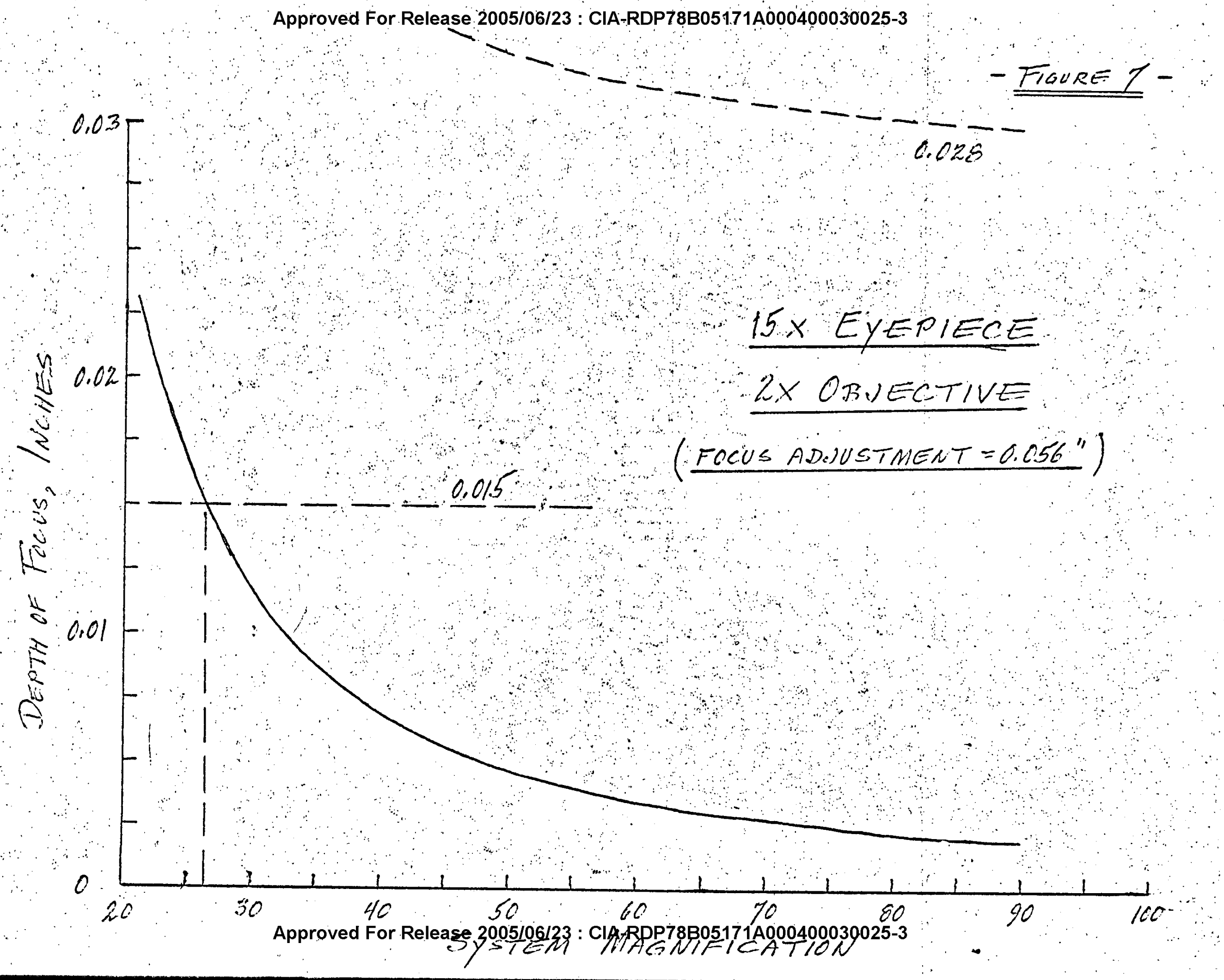
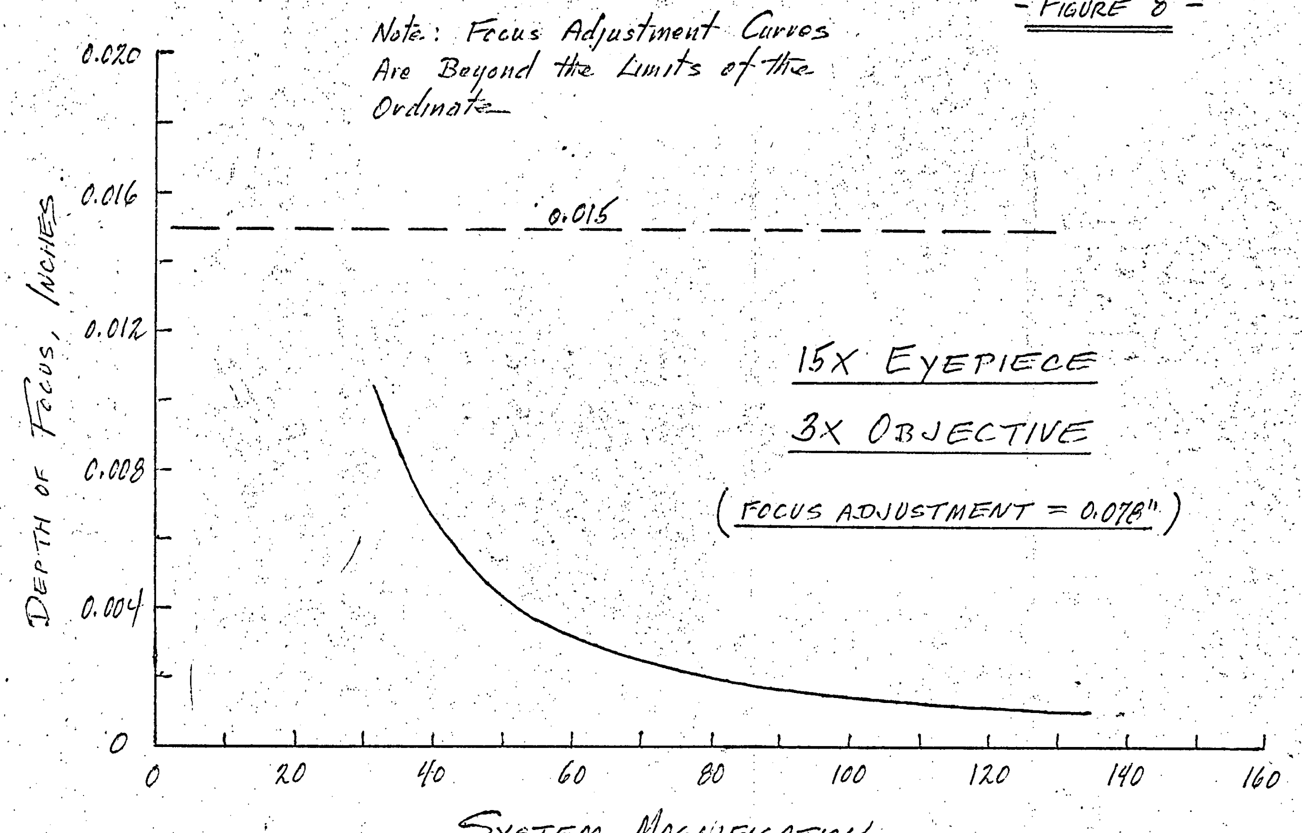
- FIGURE 7 -


0.028
0.03
0.02
0.01
0
DEPTH OF FOCUS, INCHES
0.015
15X EYEPIECE
2X OBJECTIVE
(FOCUS ADJUSTMENT = 0.056")
20
30
40
50
60
70
80
90
100
SYSTEM MAGNIFICATION

- FIGURE 8 -



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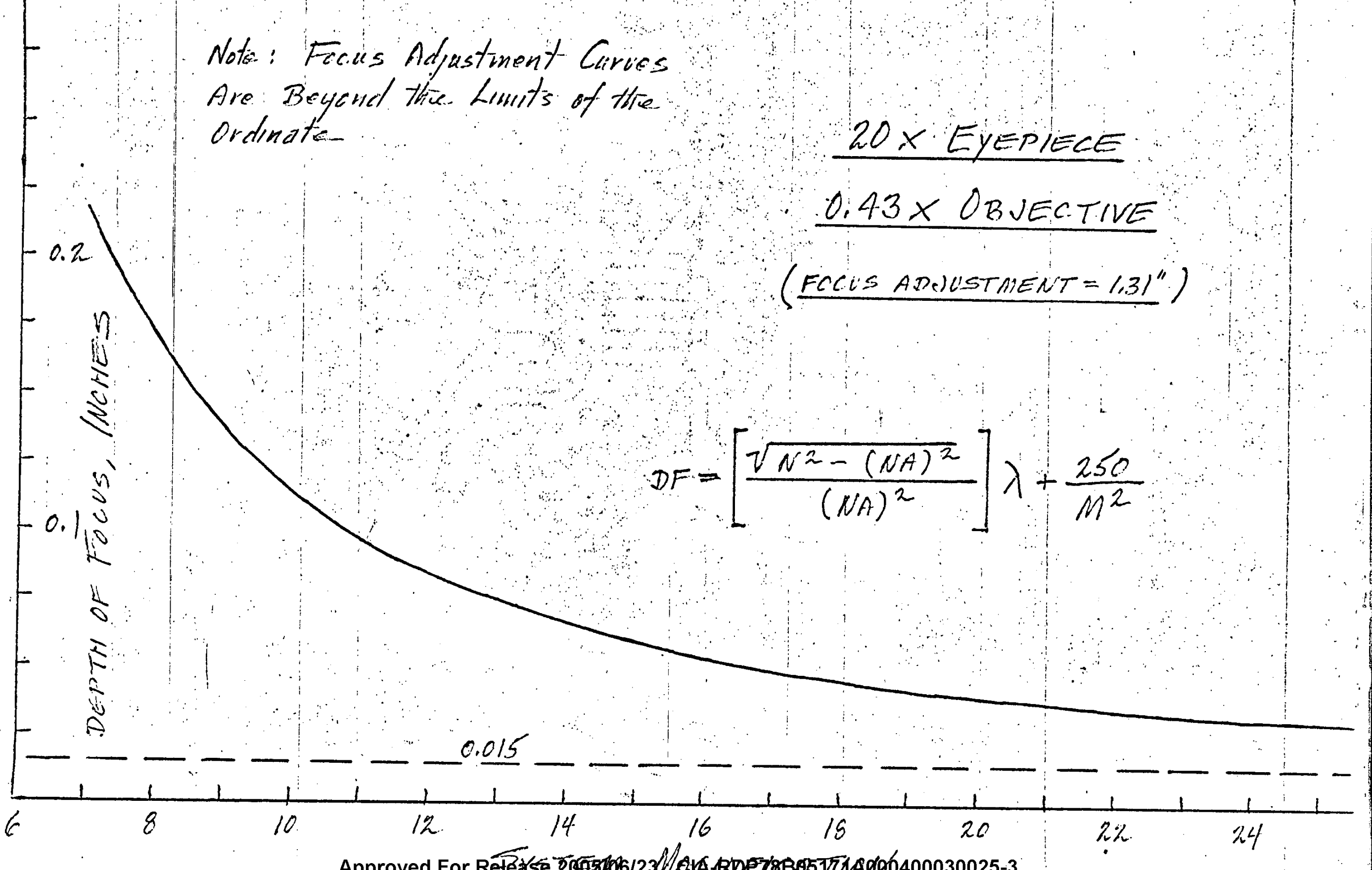
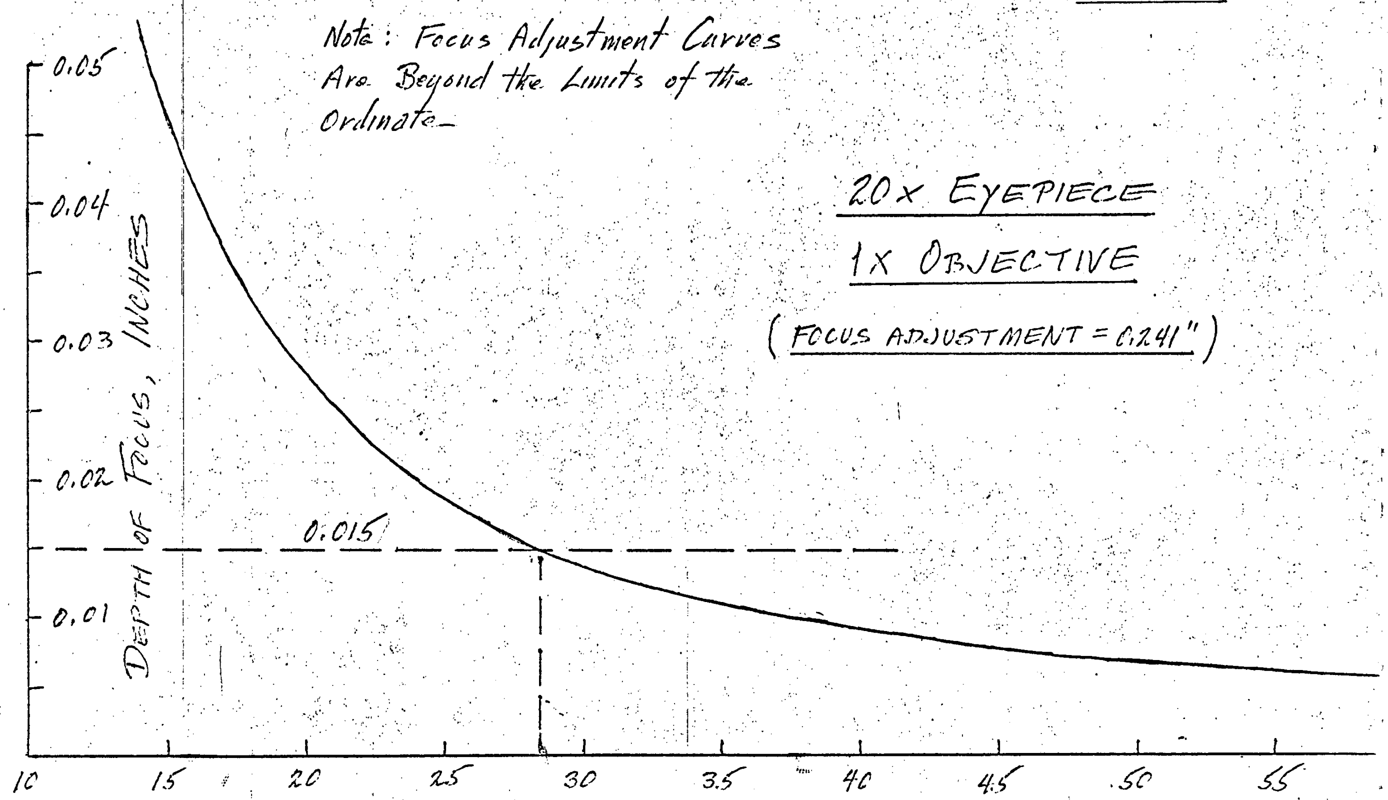
- FIGURE 9 -


Note: Focus Adjustment Curves Are Beyond the Limits of the Ordinate
20 X EYEPIECE
0.43 X OBJECTIVE
(FOCUS ADJUSTMENT = 1.31")
$DF = \left[\frac{\sqrt{N^2 - (NA)^2}}{(NA)^2} \right] \lambda + \frac{250}{M^2}$
DEPTH OF FOCUS, INCHES
0.3
0.2
0.1
0.015
6
8
10
12
14
16
18
20
22
24
SYSTEM MAGNIFICATION

— FIGURE 10 —



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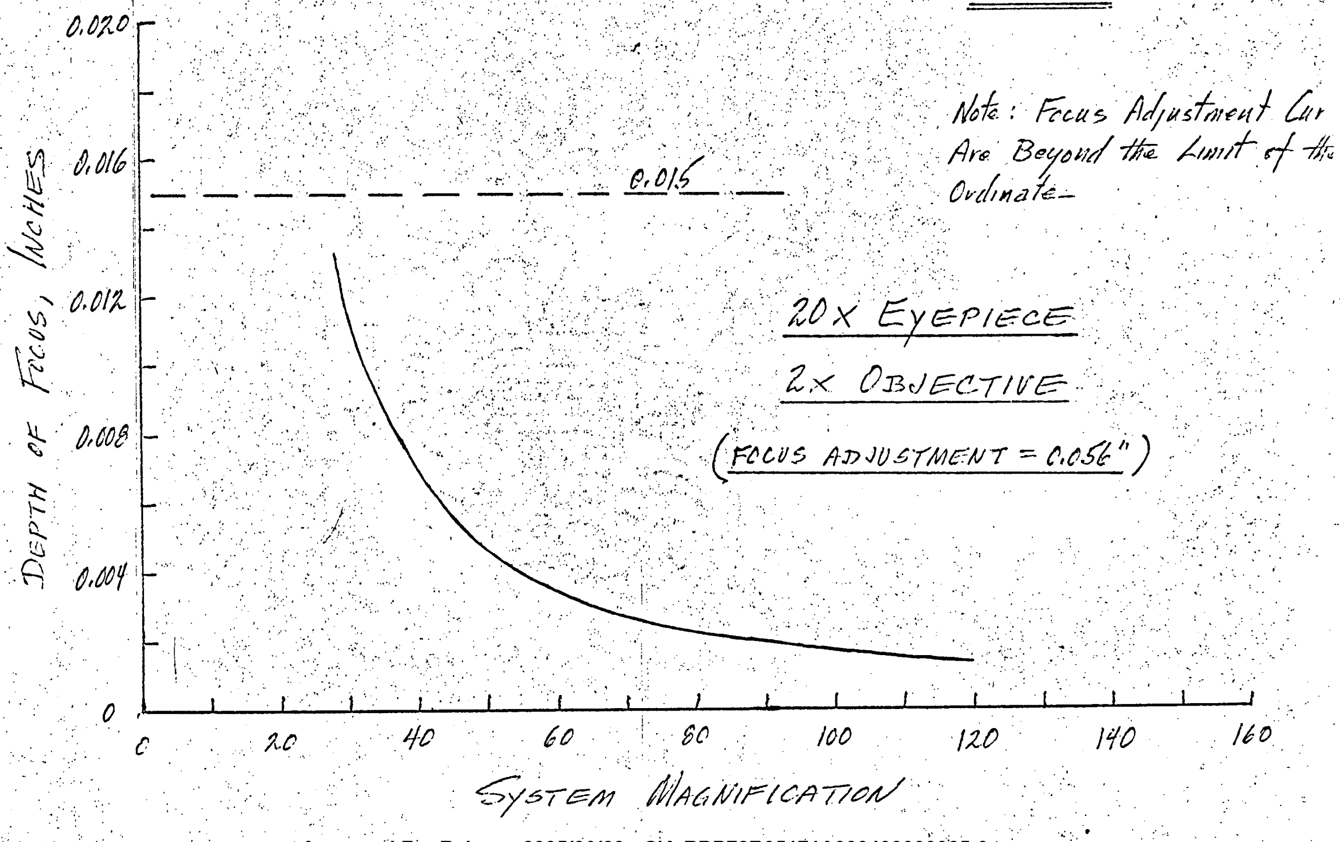
- FIGURE 11 -



Note: Focus Adjustment Cur
Are Beyond the Limit of the
Ordinate
0.015
20X EYEPIECE
2X OBJECTIVE
(FOCUS ADJUSTMENT = 0.056")
DEPTH OF FOCUS, INCHES
0.020
0.016
0.012
0.008
0.004
0
0
20
40
60
80
100
120
140
160
SYSTEM MAGNIFICATION