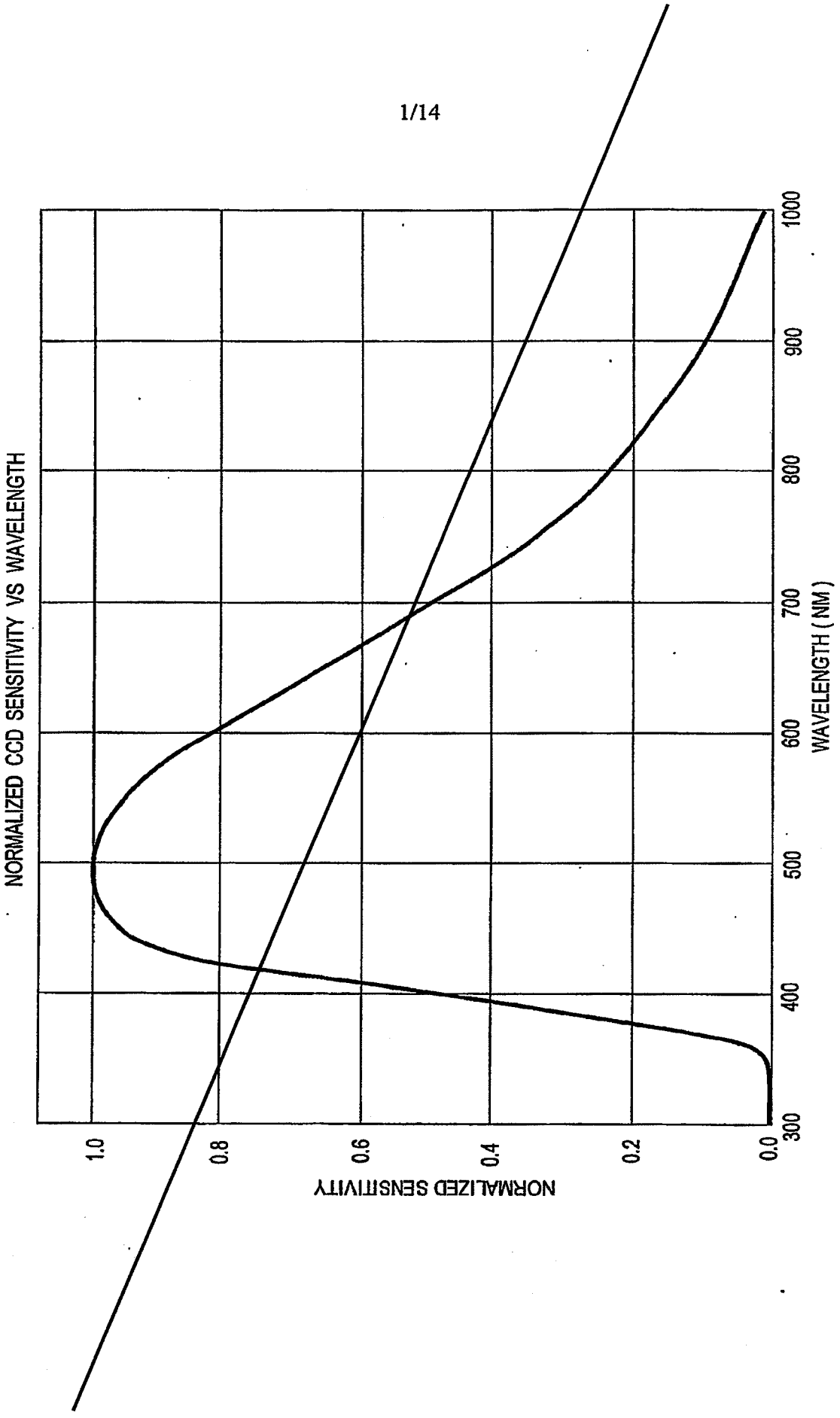

NORMALIZED CCD SENSITIVITY VS WAVELENGTH
NORMALIZED SENSITIVITY
1.0
0.8
0.6
0.4
0.2
0.0
WAVELENGTH (NM)
300
400
500
600
700
800
900
1000

FIG. 1

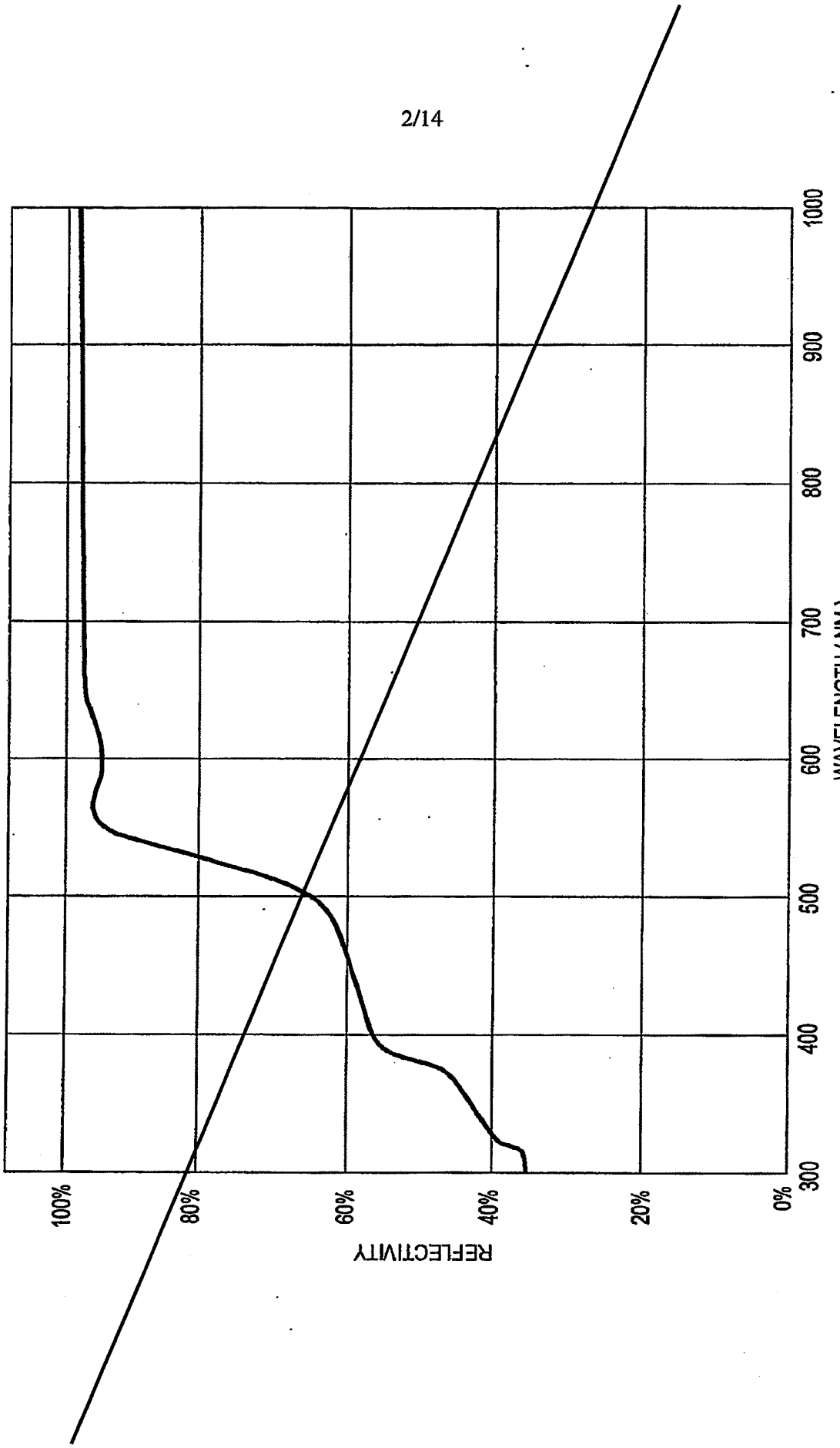

100%
80%
60%
40%
20%
0%
REFLECTIVITY
300
400
500
600
700
800
900
1000
WAVELENGTH (NM)

FIG. 2

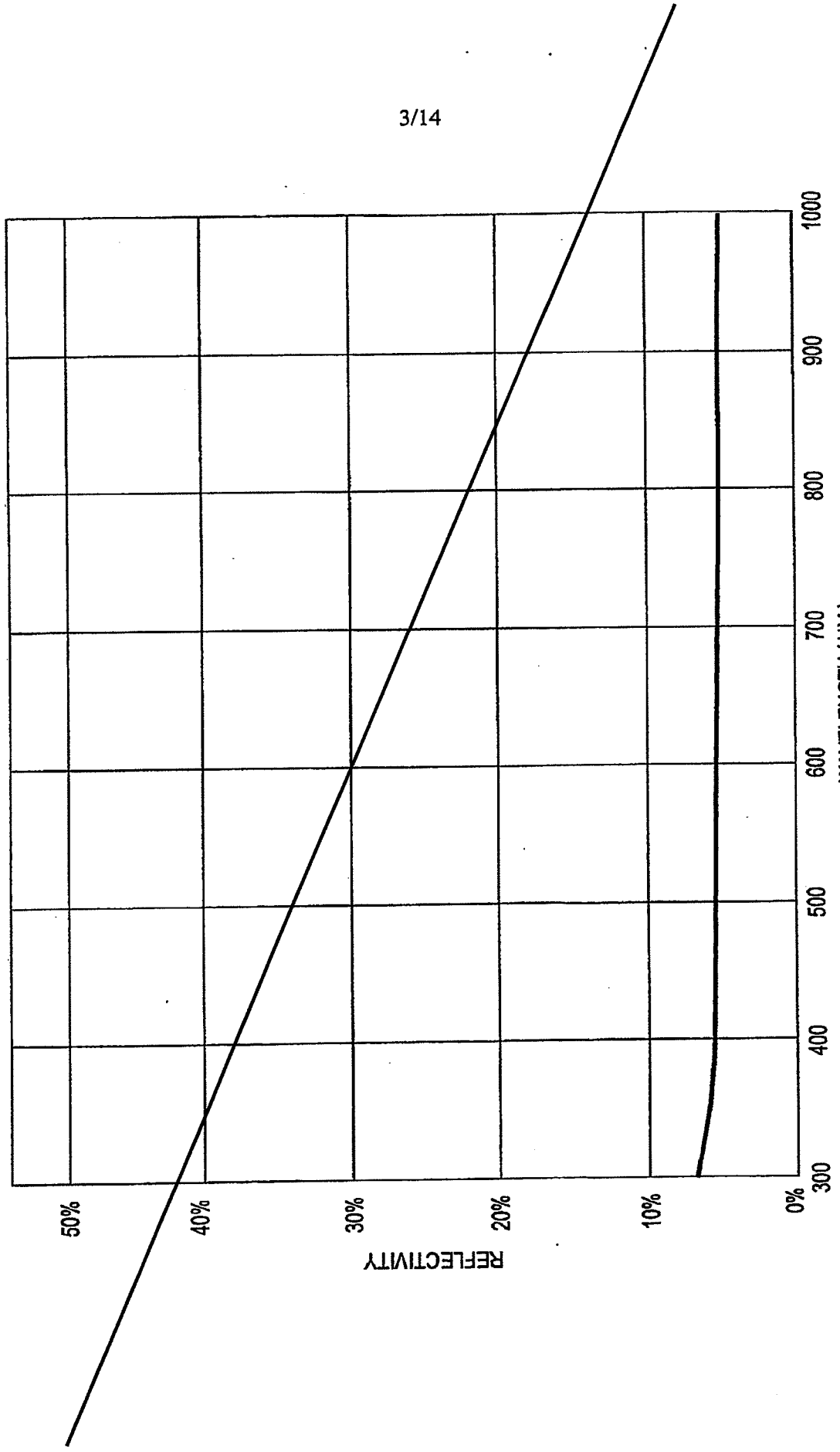

REFLECTIVITY
50%
40%
30%
20%
10%
0%
WAVELENGTH (NM)
300
400
500
600
700
800
900
1000

FIG. 3

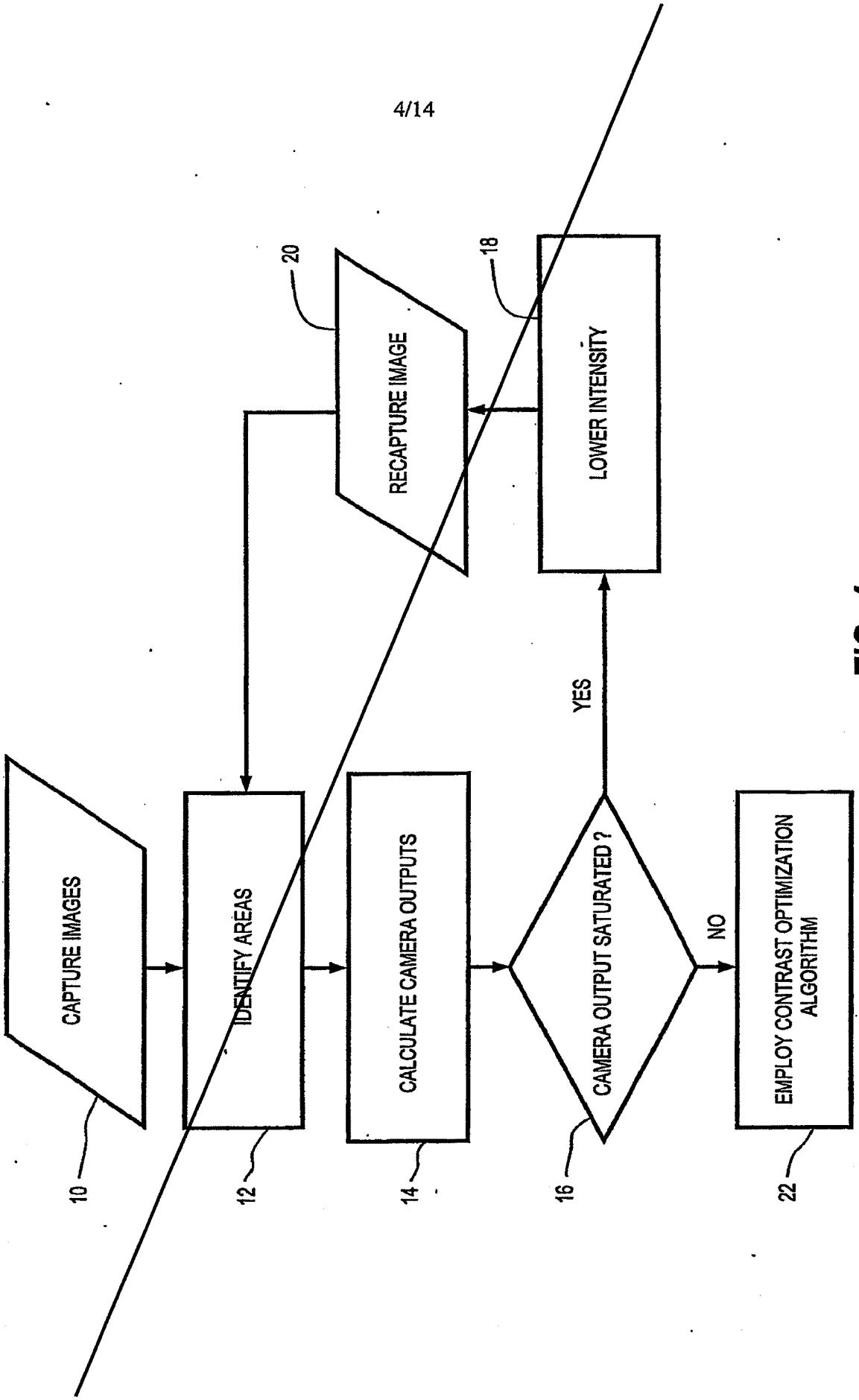

CAPTURE IMAGES
IDENTIFY AREAS
CALCULATE CAMERA OUTPUTS
CAMERA OUTPUT SATURATED ?
YES
NO
LOWER INTENSITY
RECAPTURE IMAGE
EMPLOY CONTRAST OPTIMIZATION ALGORITHM
10
12
14
16
18
20
22

FIG. 4

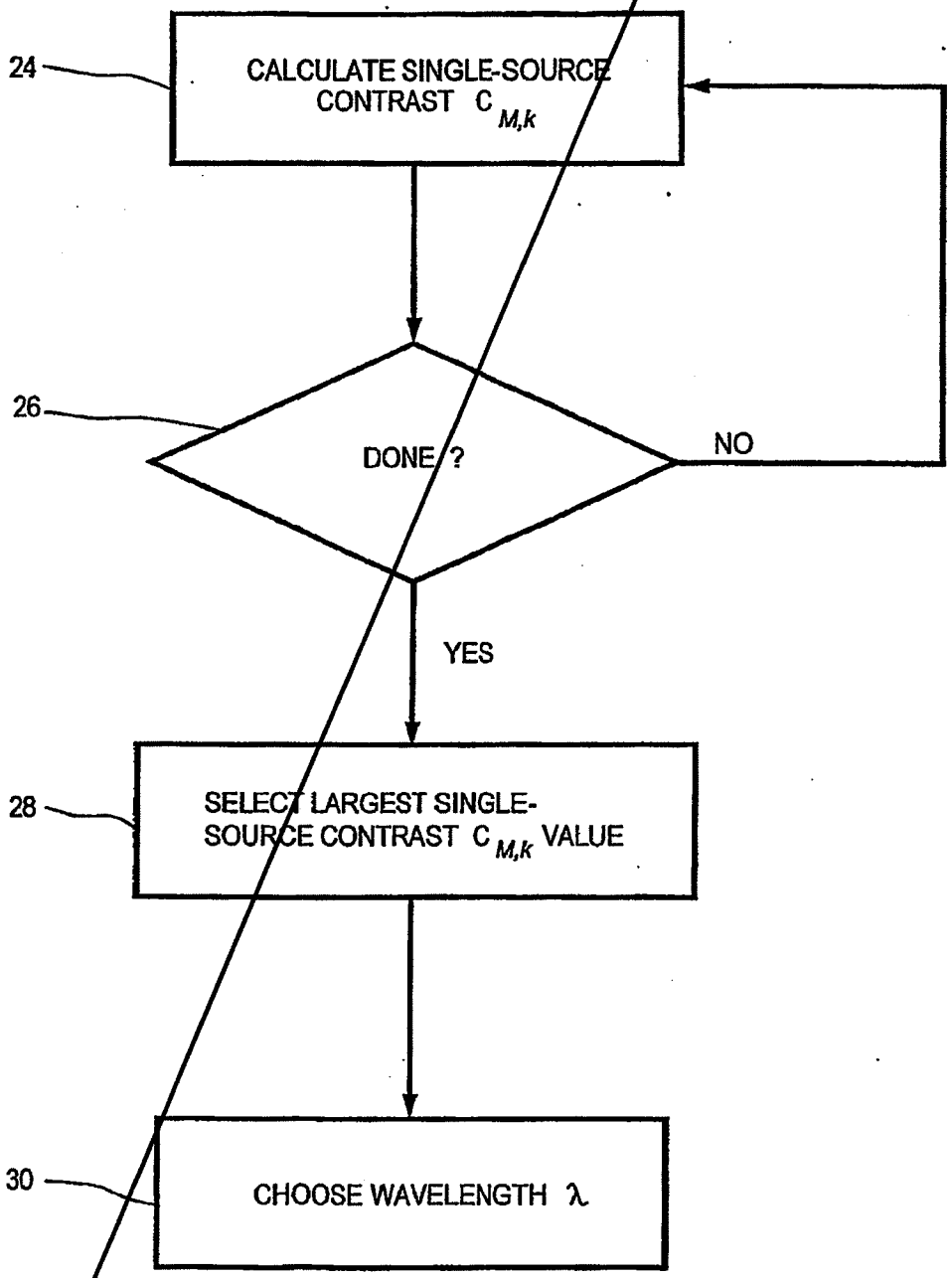

24
CALCULATE SINGLE-SOURCE CONTRAST $C_{M,k}$
26
DONE ?
NO
YES
28
SELECT LARGEST SINGLE-SOURCE CONTRAST $C_{M,k}$ VALUE
30
CHOOSE WAVELENGTH λ

FIG. 5

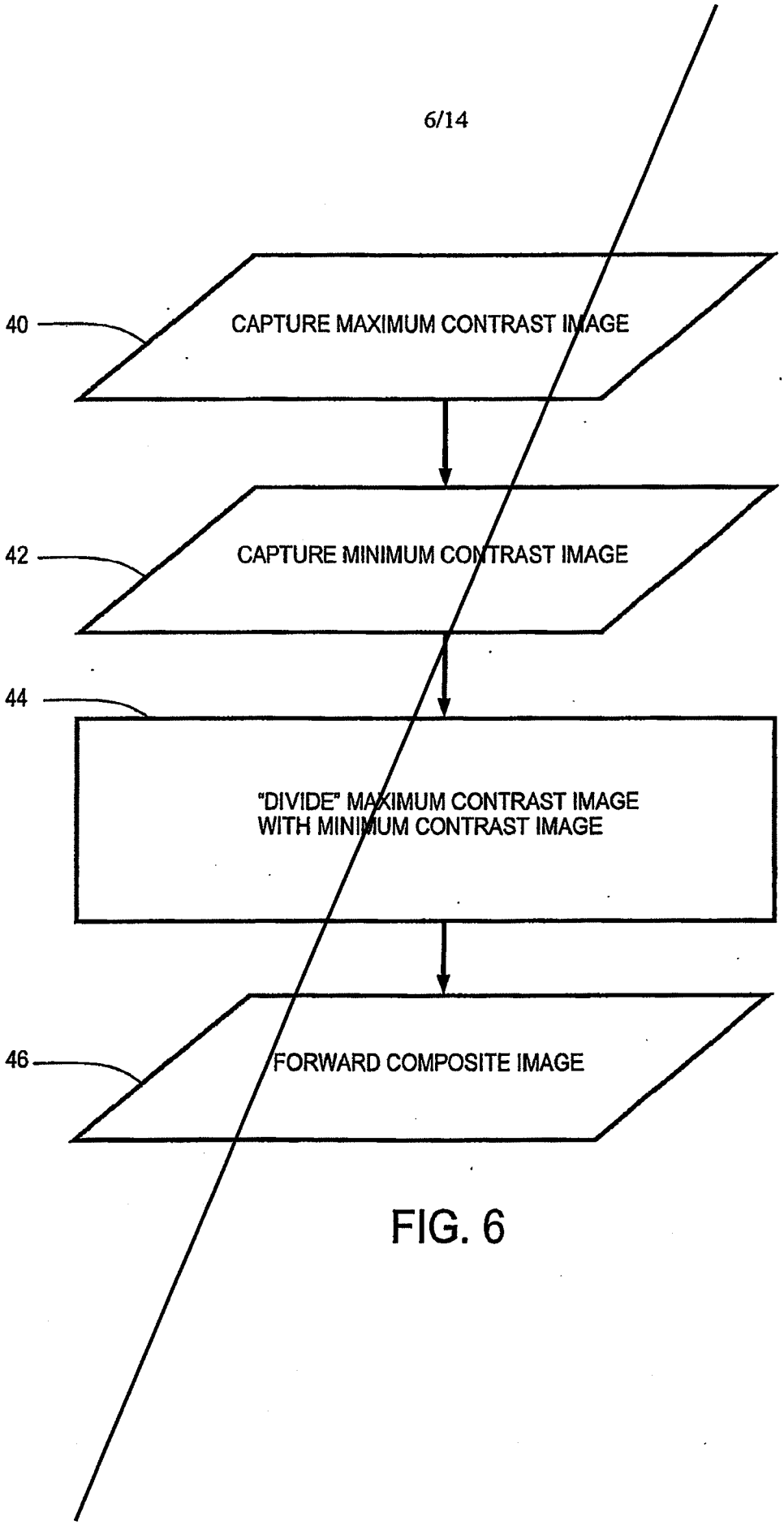

40
CAPTURE MAXIMUM CONTRAST IMAGE
42
CAPTURE MINIMUM CONTRAST IMAGE
44
"DIVIDE" MAXIMUM CONTRAST IMAGE
WITH MINIMUM CONTRAST IMAGE
46
FORWARD COMPOSITE IMAGE

FIG. 6

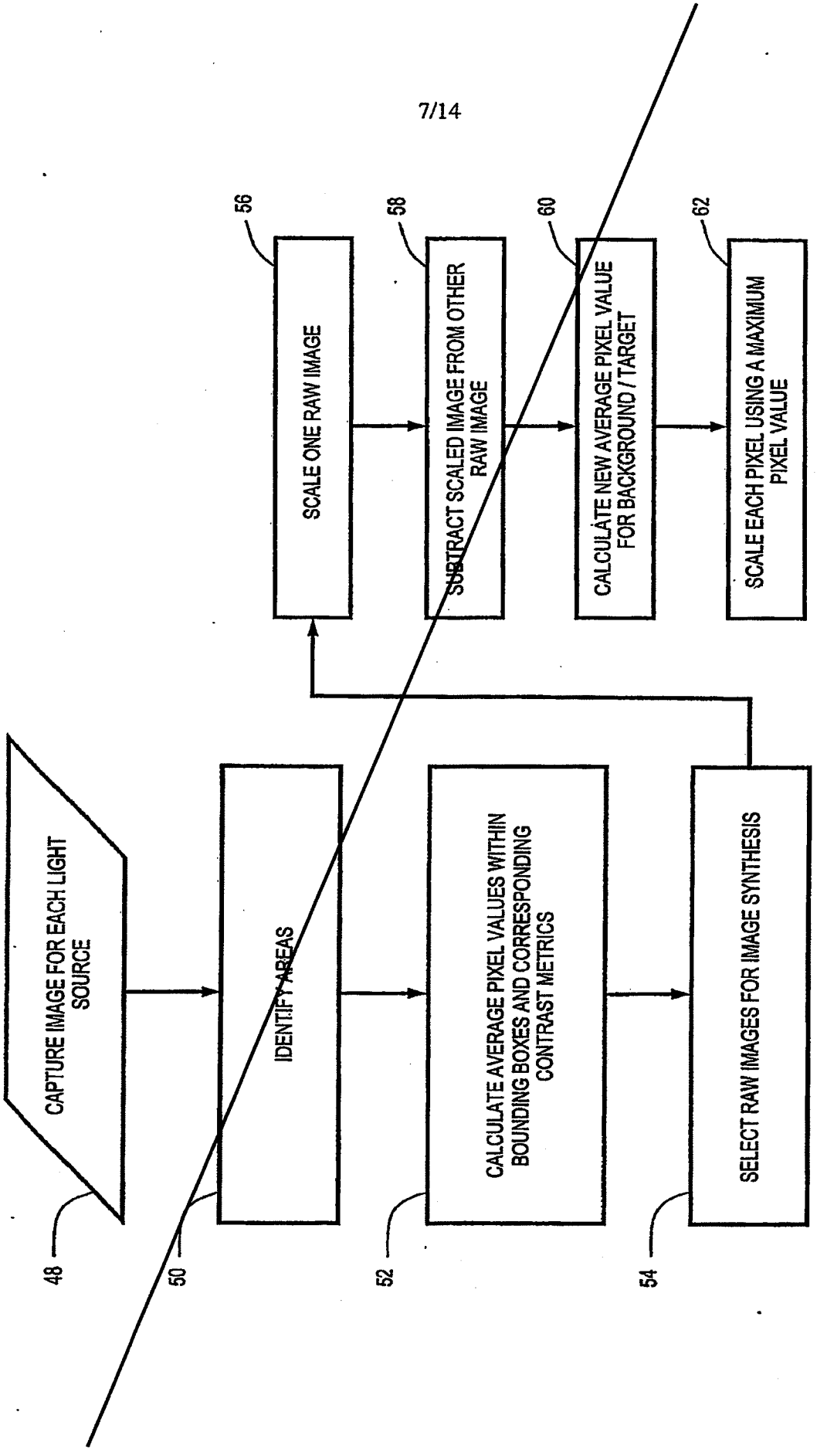

CAPTURE IMAGE FOR EACH LIGHT SOURCE
IDENTIFY AREAS
CALCULATE AVERAGE PIXEL VALUES WITHIN BOUNDING BOXES AND CORRESPONDING CONTRAST METRICS
SELECT RAW IMAGES FOR IMAGE SYNTHESIS
SCALE ONE RAW IMAGE
SUBTRACT SCALED IMAGE FROM OTHER RAW IMAGE
CALCULATE NEW AVERAGE PIXEL VALUE FOR BACKGROUND / TARGET
SCALE EACH PIXEL USING A MAXIMUM PIXEL VALUE
48
50
52
54
56
58
60
62

FIG. 7

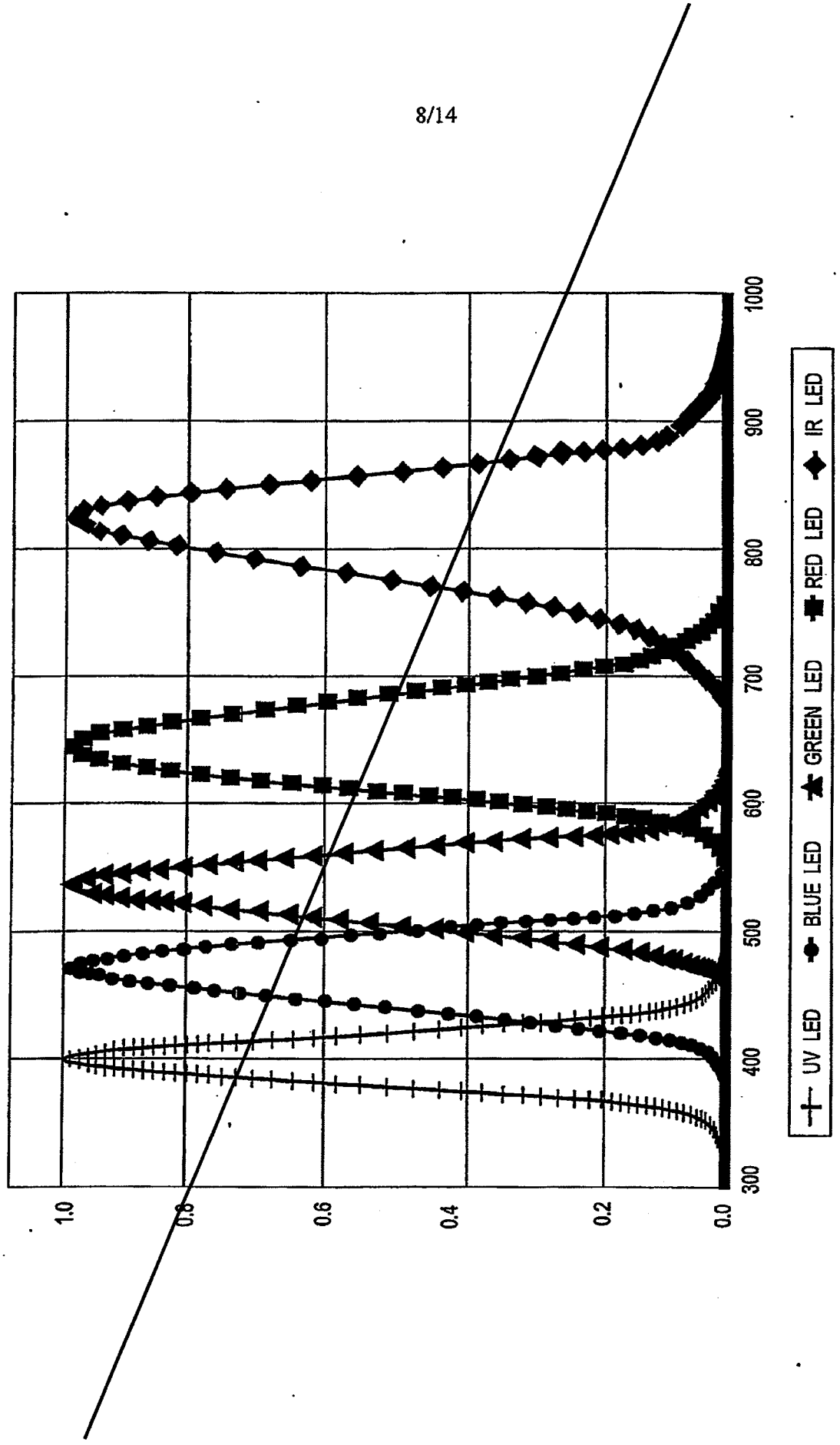

1.0
0.8
0.6
0.4
0.2
0.0
300
400
500
600
700
800
900
1000
UV LED
BLUE LED
GREEN LED
RED LED
IR LED

FIG. 8

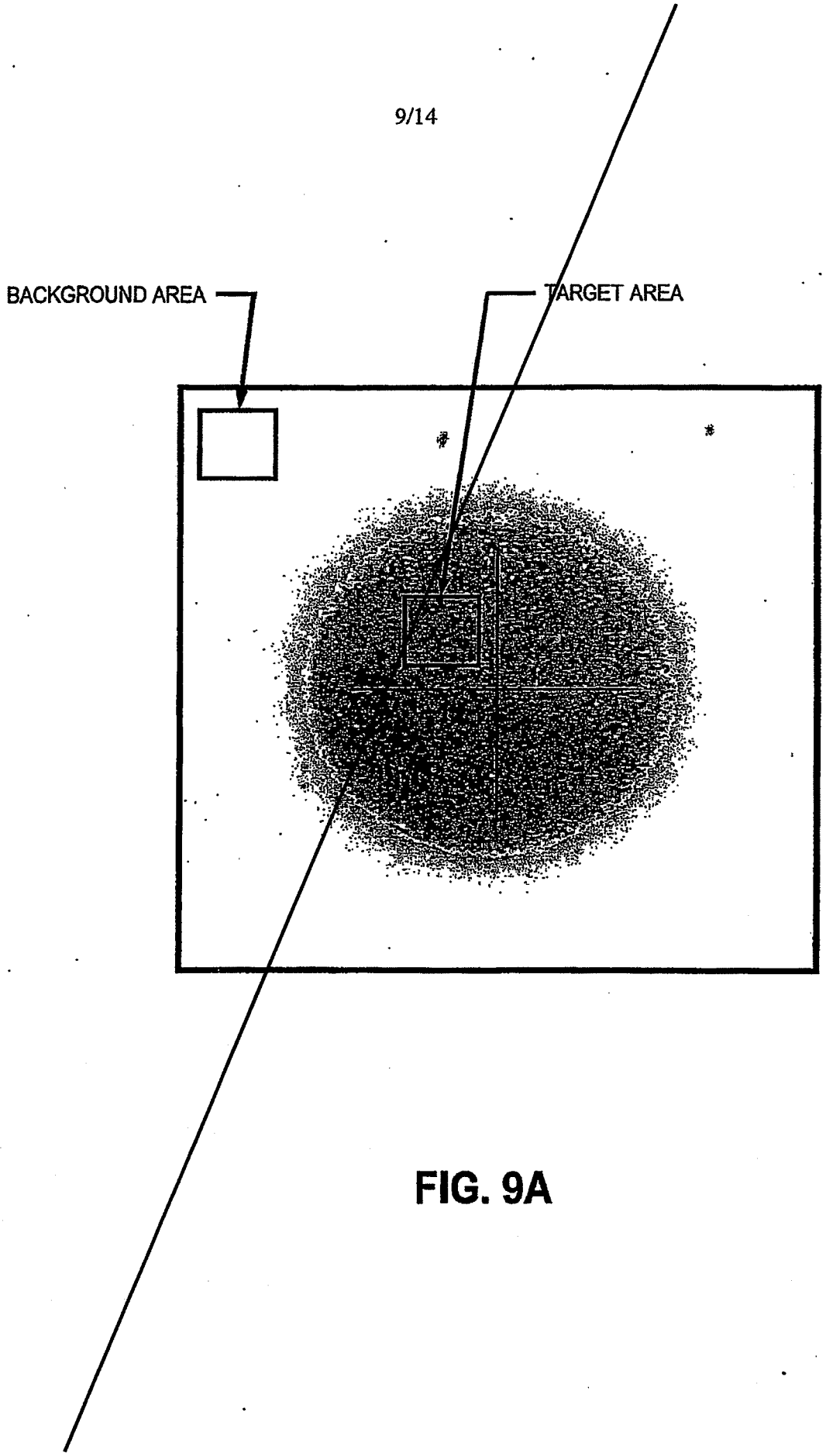


FIG. 9A

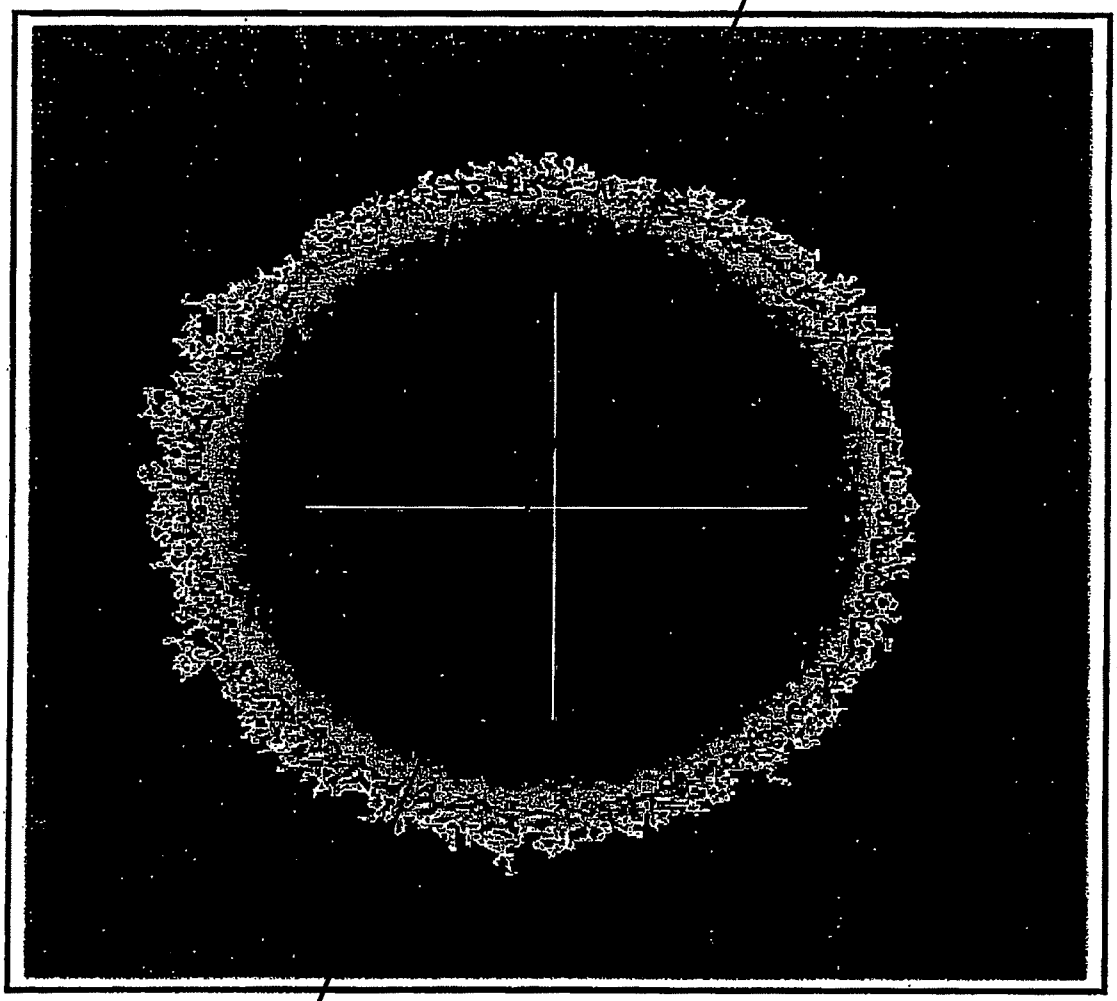


FIG. 9B

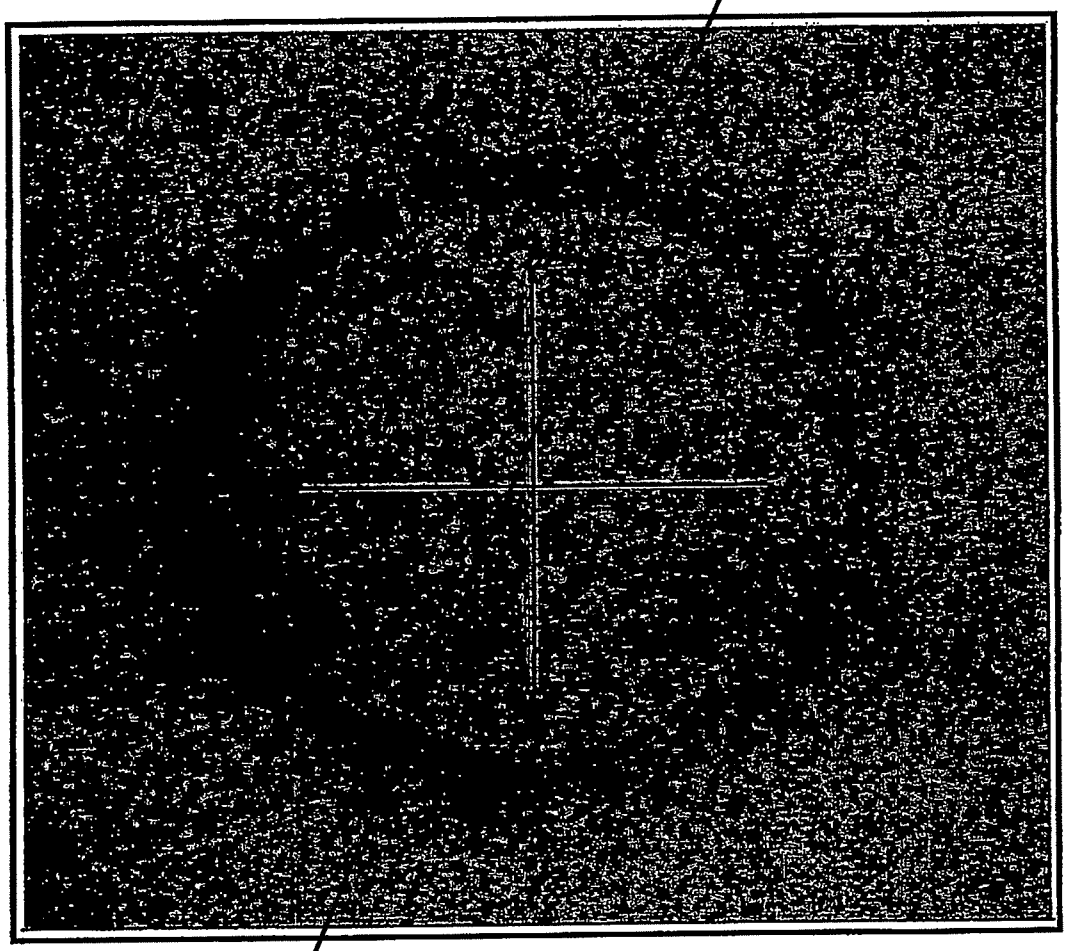


FIG. 9C

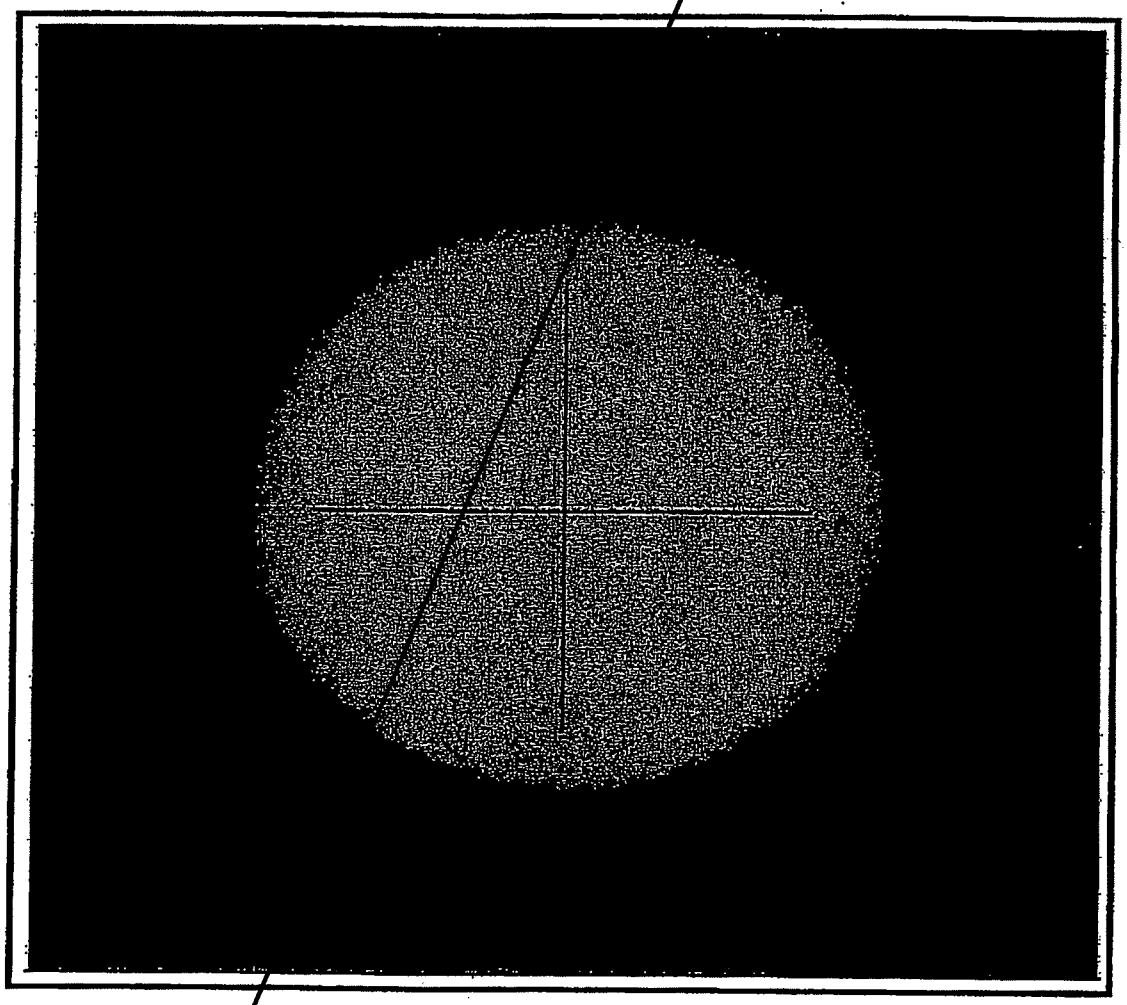


FIG. 9D

LIGHTING SCHEME	BACKGROUND AVERAGE PIXEL VALUE	TARGET AVERAGE PIXEL VALUE	CONTRAST METRIC
BLUE LEDS	246.9604	144.1300	0.2629
GREEN LEDS	101.7078	63.2830	0.2329
RED LEDS	118.2418	119.6117	0.0058
IR LEDS	81.2057	125.7639	0.2153

FIG. 10

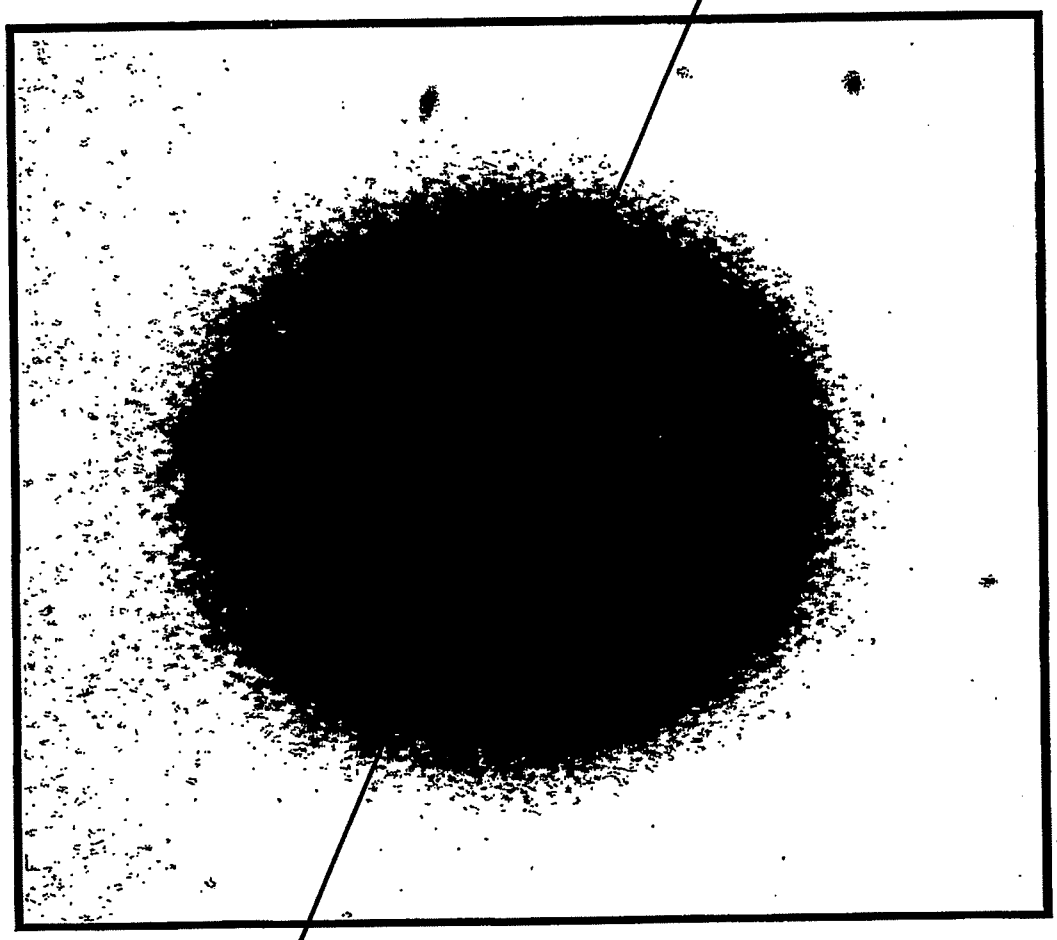


FIG. 11

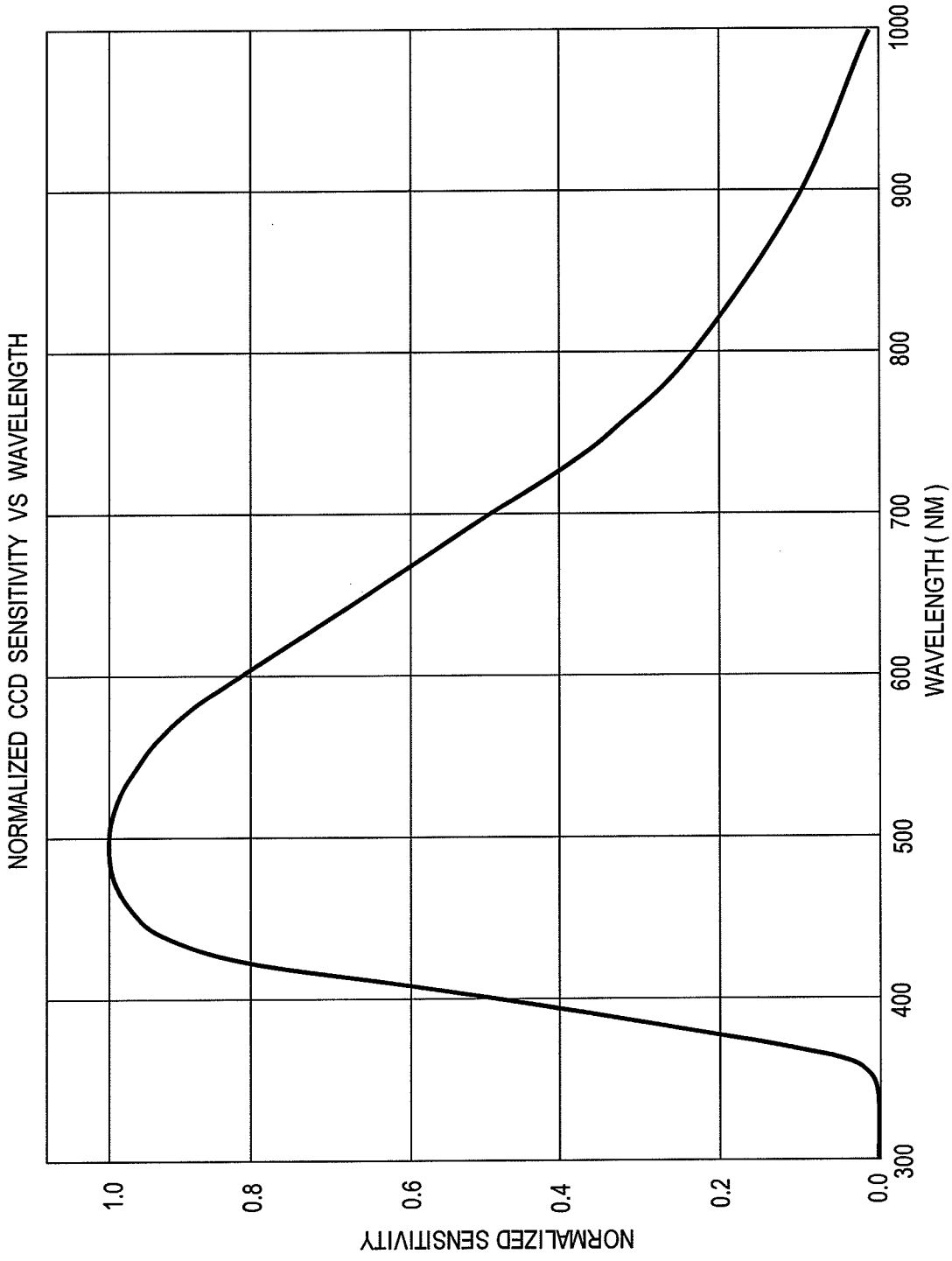

NORMALIZED CCD SENSITIVITY VS WAVELENGTH
NORMALIZED SENSITIVITY
1.0
0.8
0.6
0.4
0.2
0.0
300
400
500
600
700
800
900
1000
WAVELENGTH (NM)

FIG. 1

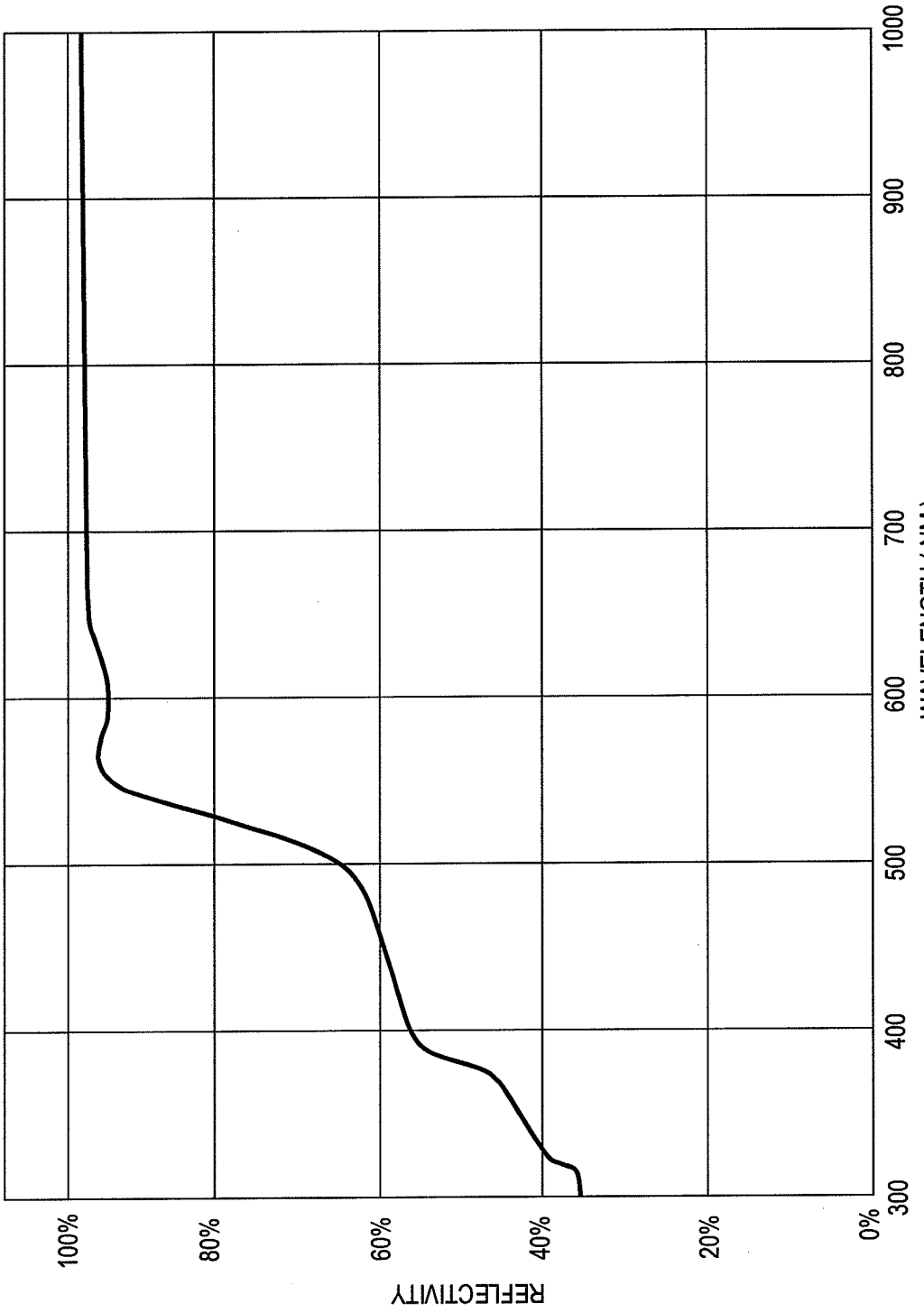

100%
80%
60%
40%
20%
0%
REFLECTIVITY
300
400
500
600
700
800
900
1000
WAVELENGTH (NM)

FIG. 2

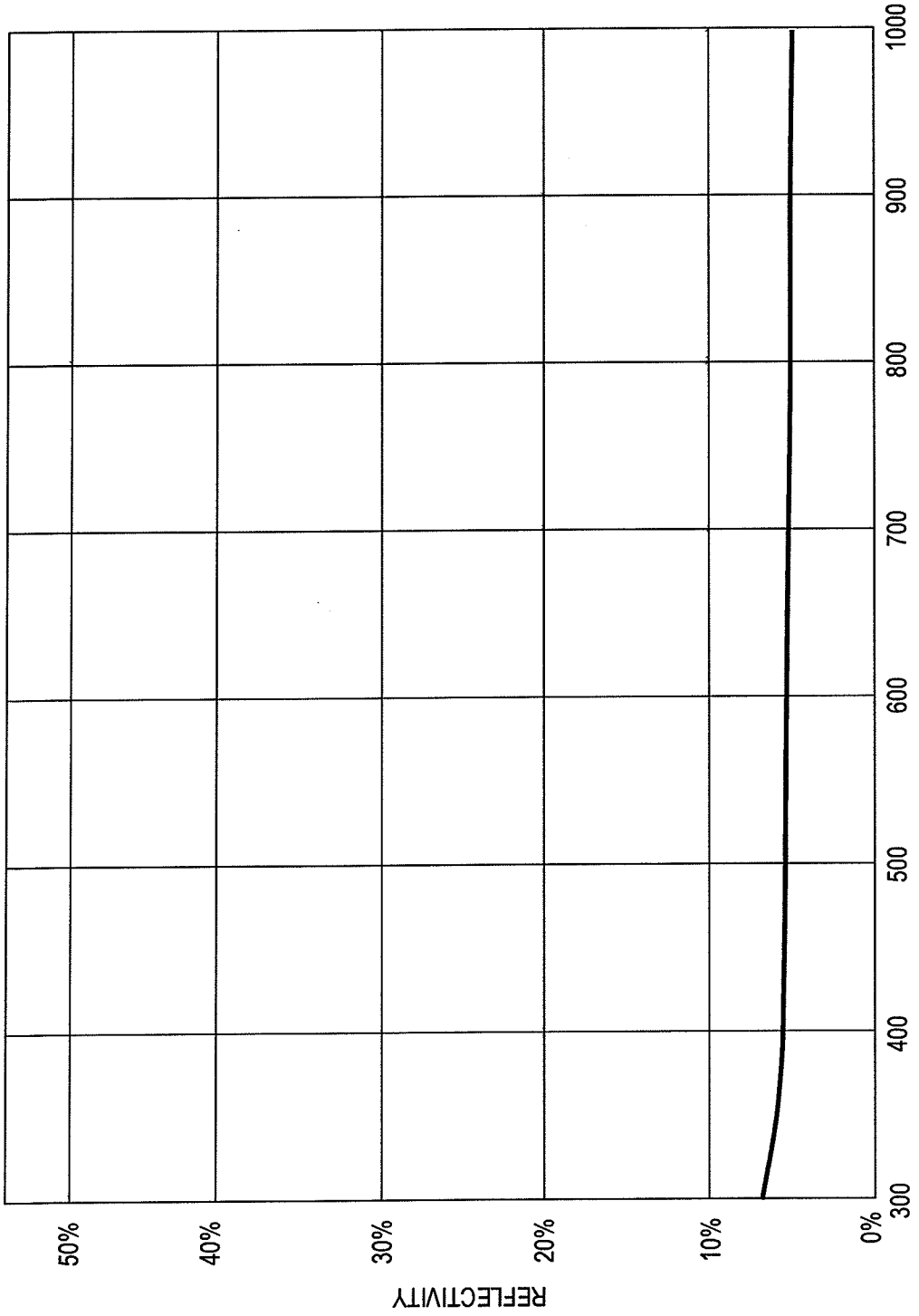

50%
40%
30%
20%
10%
0%
REFLECTIVITY
300
400
500
600
700
800
900
1000
WAVELENGTH (NM)

FIG. 3

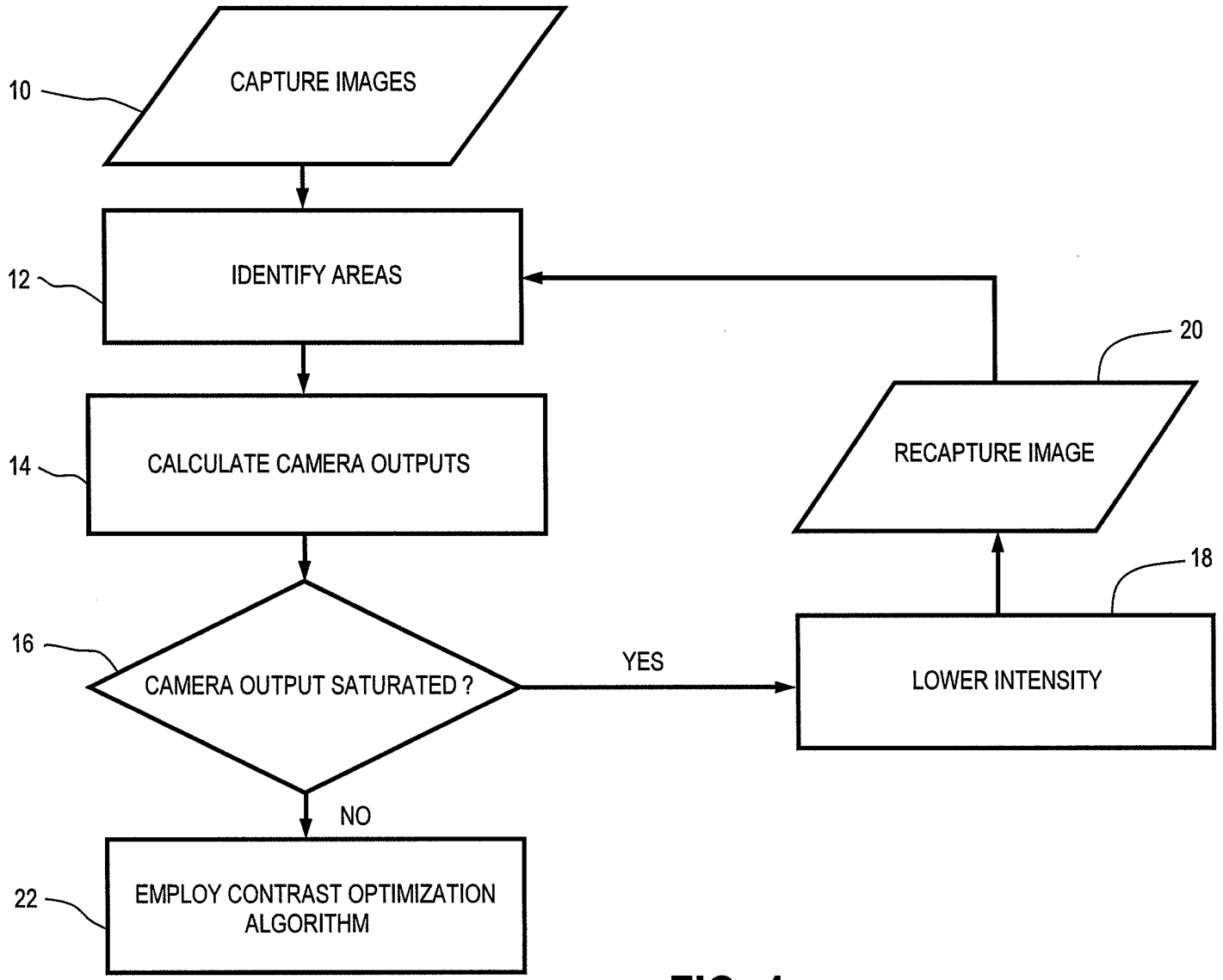

10
CAPTURE IMAGES
12
IDENTIFY AREAS
14
CALCULATE CAMERA OUTPUTS
16
CAMERA OUTPUT SATURATED ?
YES
NO
18
LOWER INTENSITY
20
RECAPTURE IMAGE
22
EMPLOY CONTRAST OPTIMIZATION ALGORITHM

FIG. 4

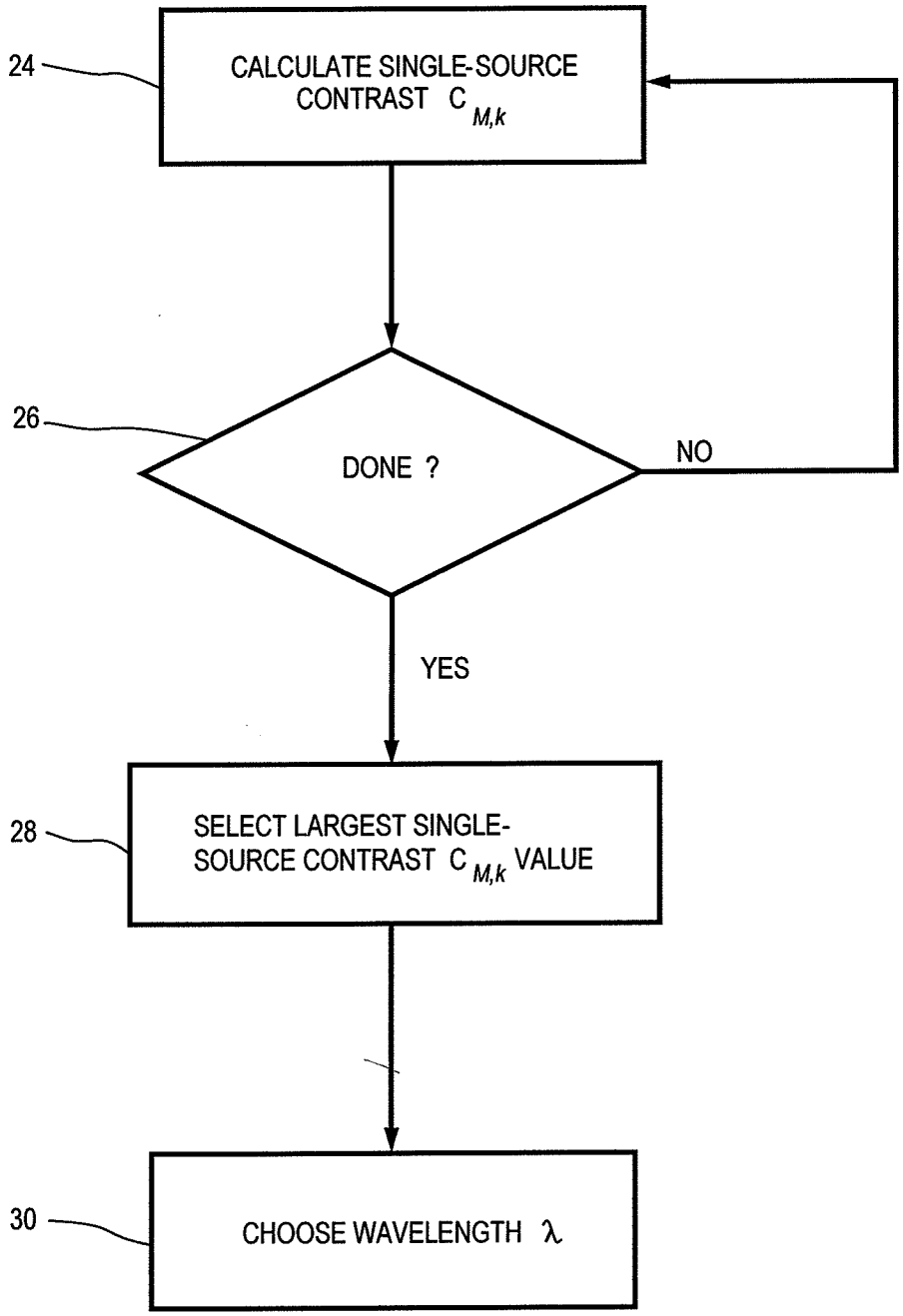

24
CALCULATE SINGLE-SOURCE CONTRAST $C_{M,k}$
26
DONE ?
NO
YES
28
SELECT LARGEST SINGLE-SOURCE CONTRAST $C_{M,k}$ VALUE
30
CHOOSE WAVELENGTH λ

FIG. 5

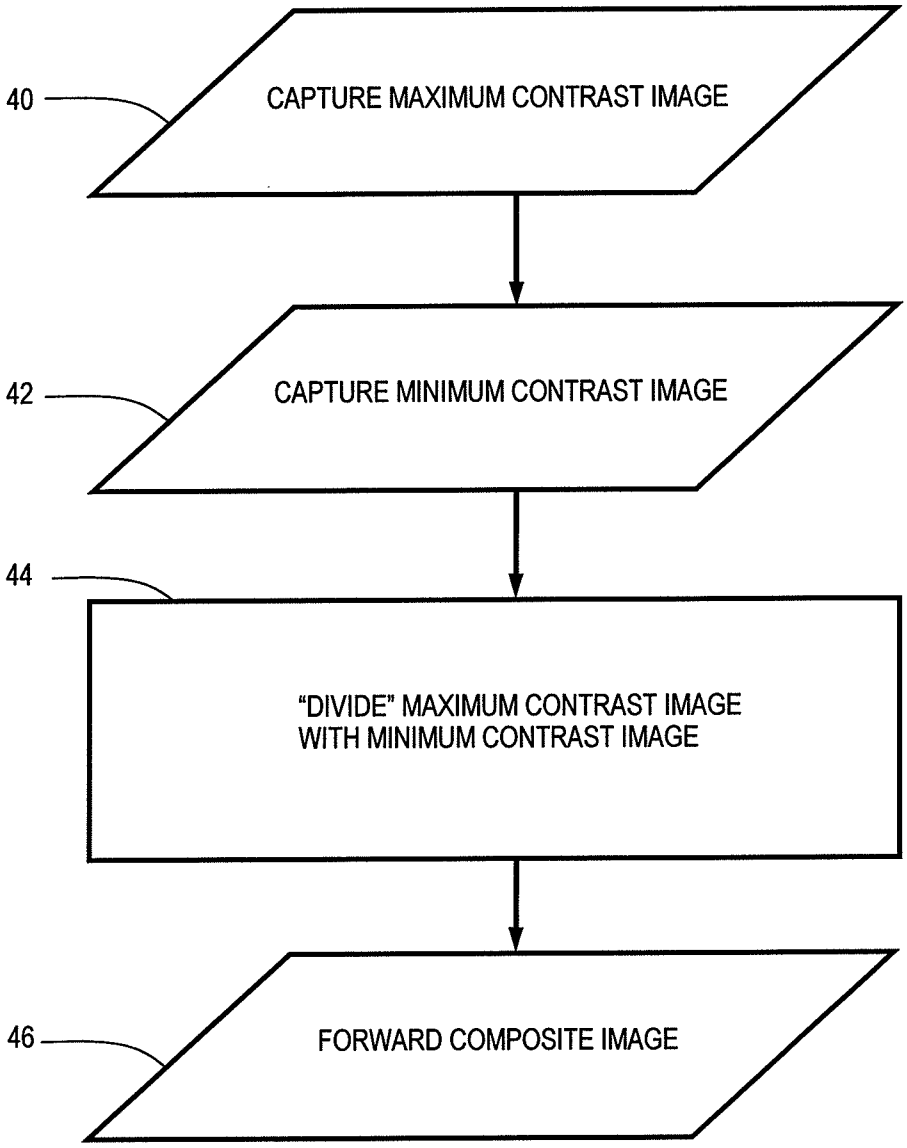

40
CAPTURE MAXIMUM CONTRAST IMAGE
42
CAPTURE MINIMUM CONTRAST IMAGE
44
"DIVIDE" MAXIMUM CONTRAST IMAGE
WITH MINIMUM CONTRAST IMAGE
46
FORWARD COMPOSITE IMAGE

FIG. 6

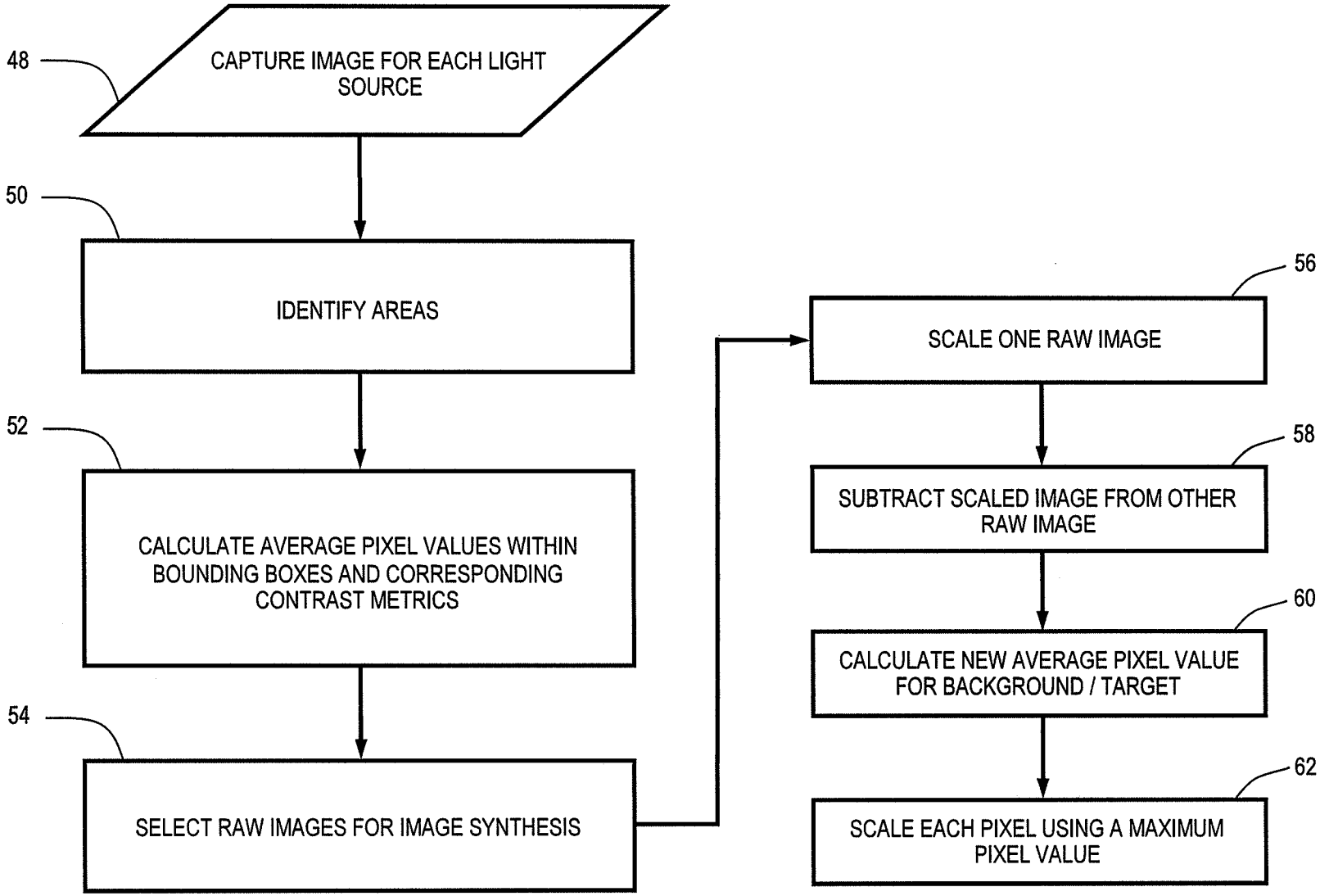

48
CAPTURE IMAGE FOR EACH LIGHT SOURCE
50
IDENTIFY AREAS
52
CALCULATE AVERAGE PIXEL VALUES WITHIN BOUNDING BOXES AND CORRESPONDING CONTRAST METRICS
54
SELECT RAW IMAGES FOR IMAGE SYNTHESIS
56
SCALE ONE RAW IMAGE
58
SUBTRACT SCALED IMAGE FROM OTHER RAW IMAGE
60
CALCULATE NEW AVERAGE PIXEL VALUE FOR BACKGROUND / TARGET
62
SCALE EACH PIXEL USING A MAXIMUM PIXEL VALUE

FIG. 7

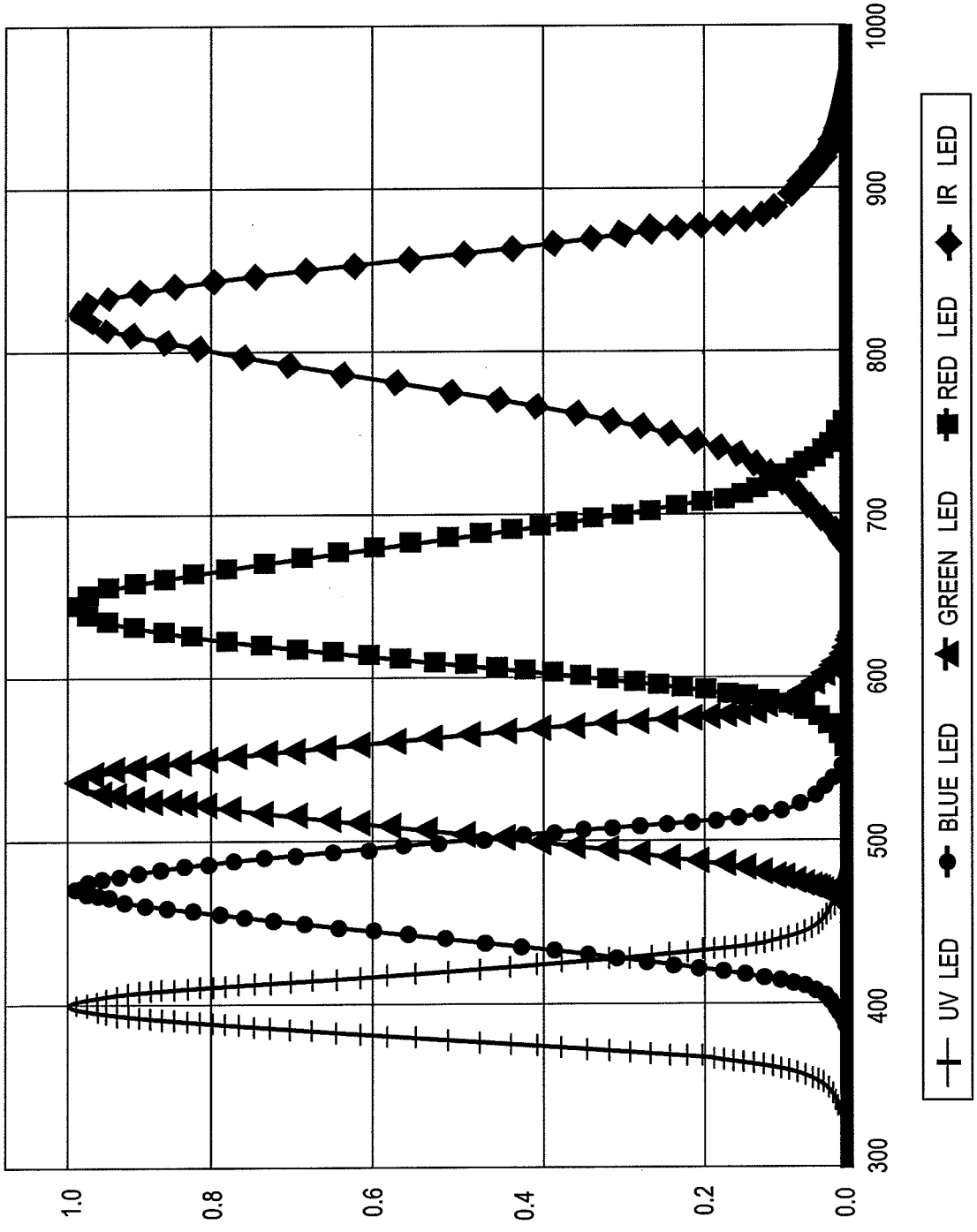

1.0
0.8
0.6
0.4
0.2
0.0
300
400
500
600
700
800
900
1000
UV LED
BLUE LED
GREEN LED
RED LED
IR LED

FIG. 8

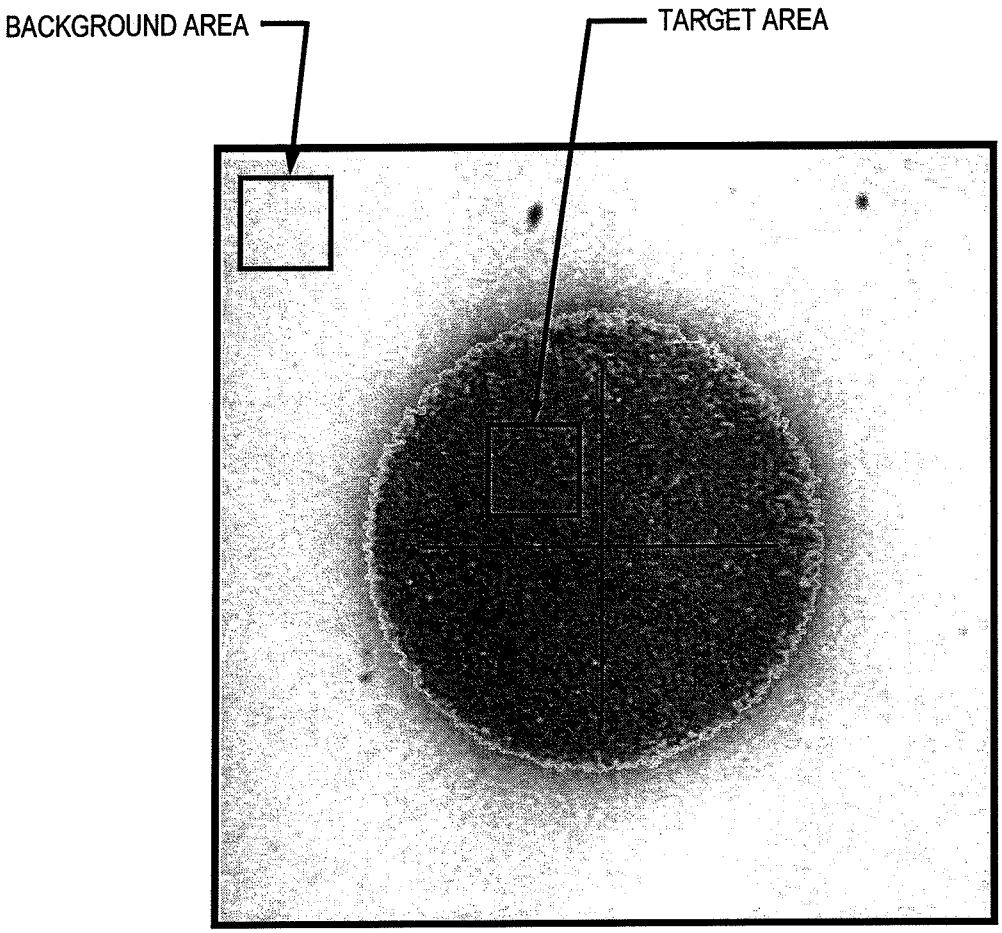


FIG. 9A

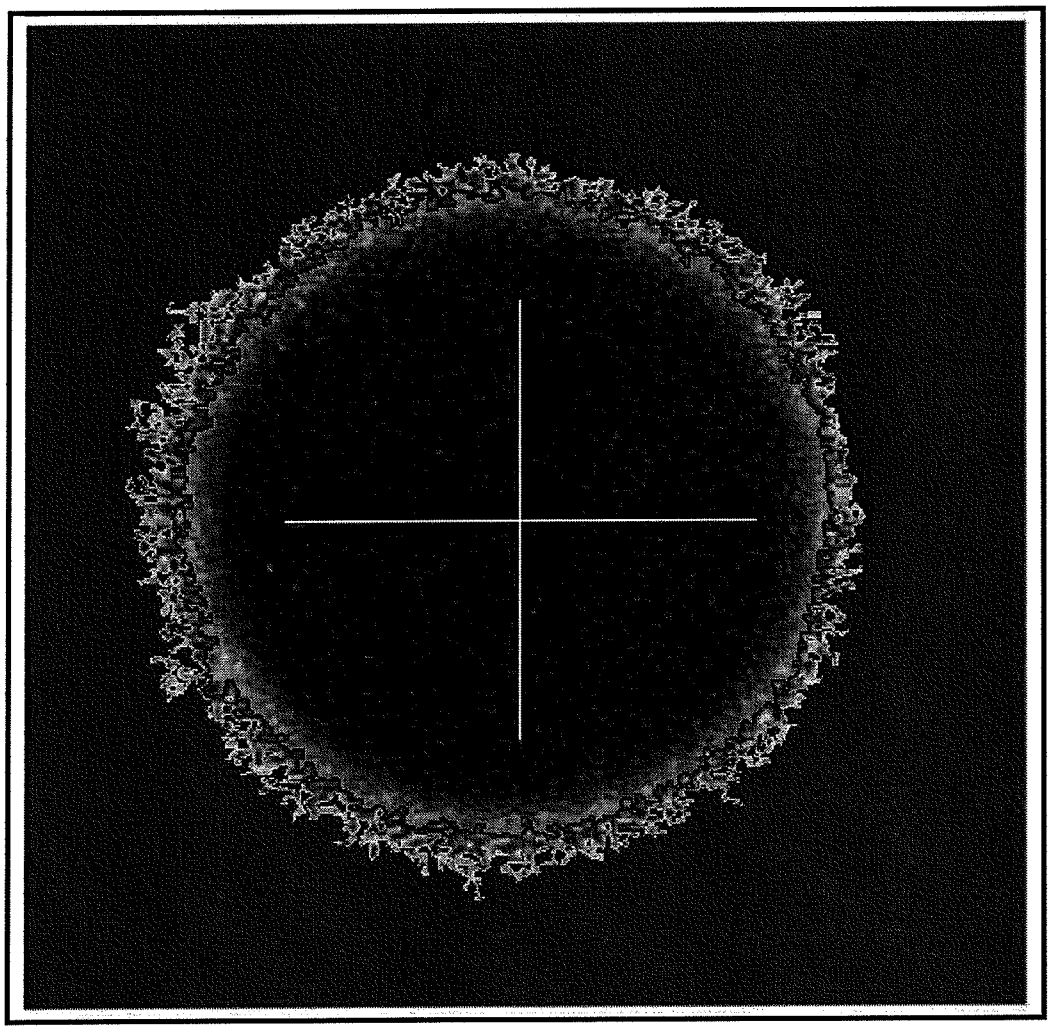


FIG. 9B

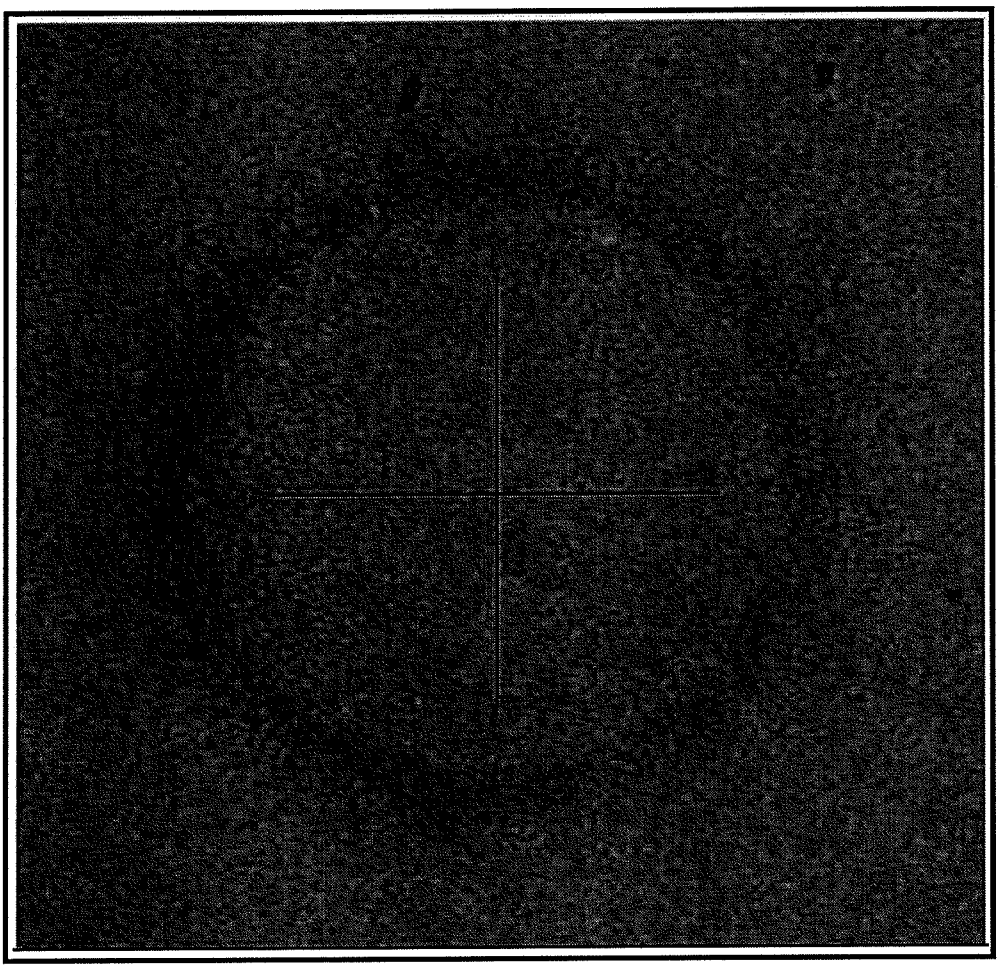


FIG. 9C

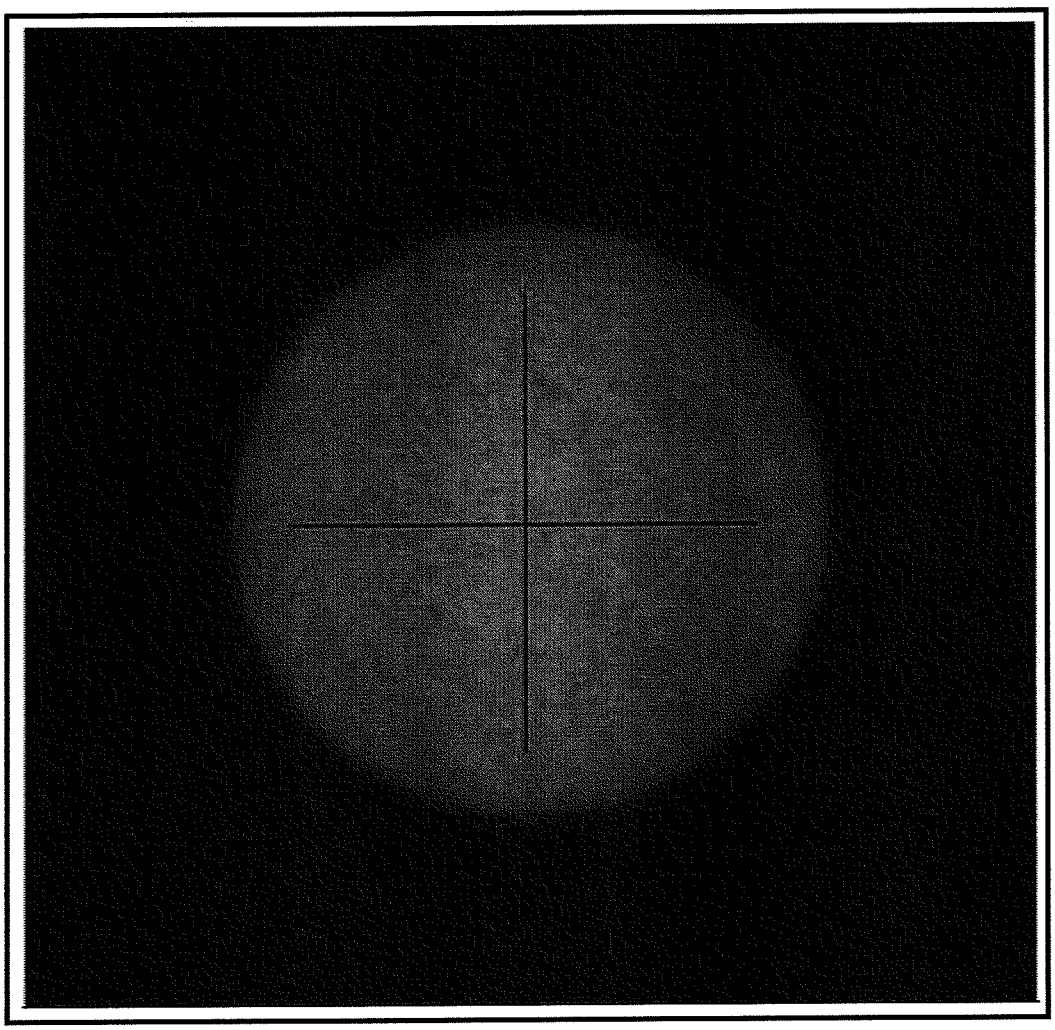


FIG. 9D

LIGHTING SCHEME	BACKGROUND AVERAGE PIXEL VALUE	TARGET AVERAGE PIXEL VALUE	CONTRAST METRIC
BLUE LEDS	246.9604	144.1300	0.2629
GREEN LEDS	101.7078	63.2830	0.2329
RED LEDS	118.2418	119.6117	0.0058
IR LEDS	81.2057	125.7639	0.2153

FIG. 10

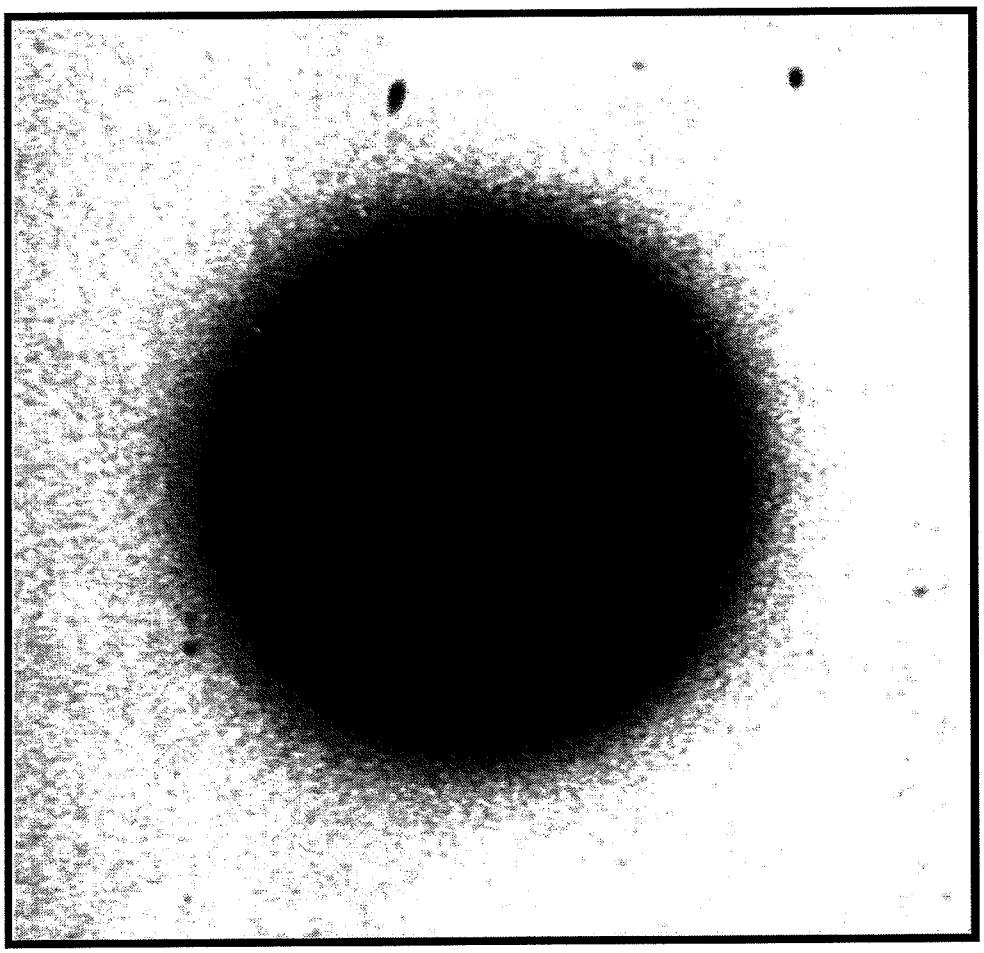


FIG. 11