24 JAN 2005

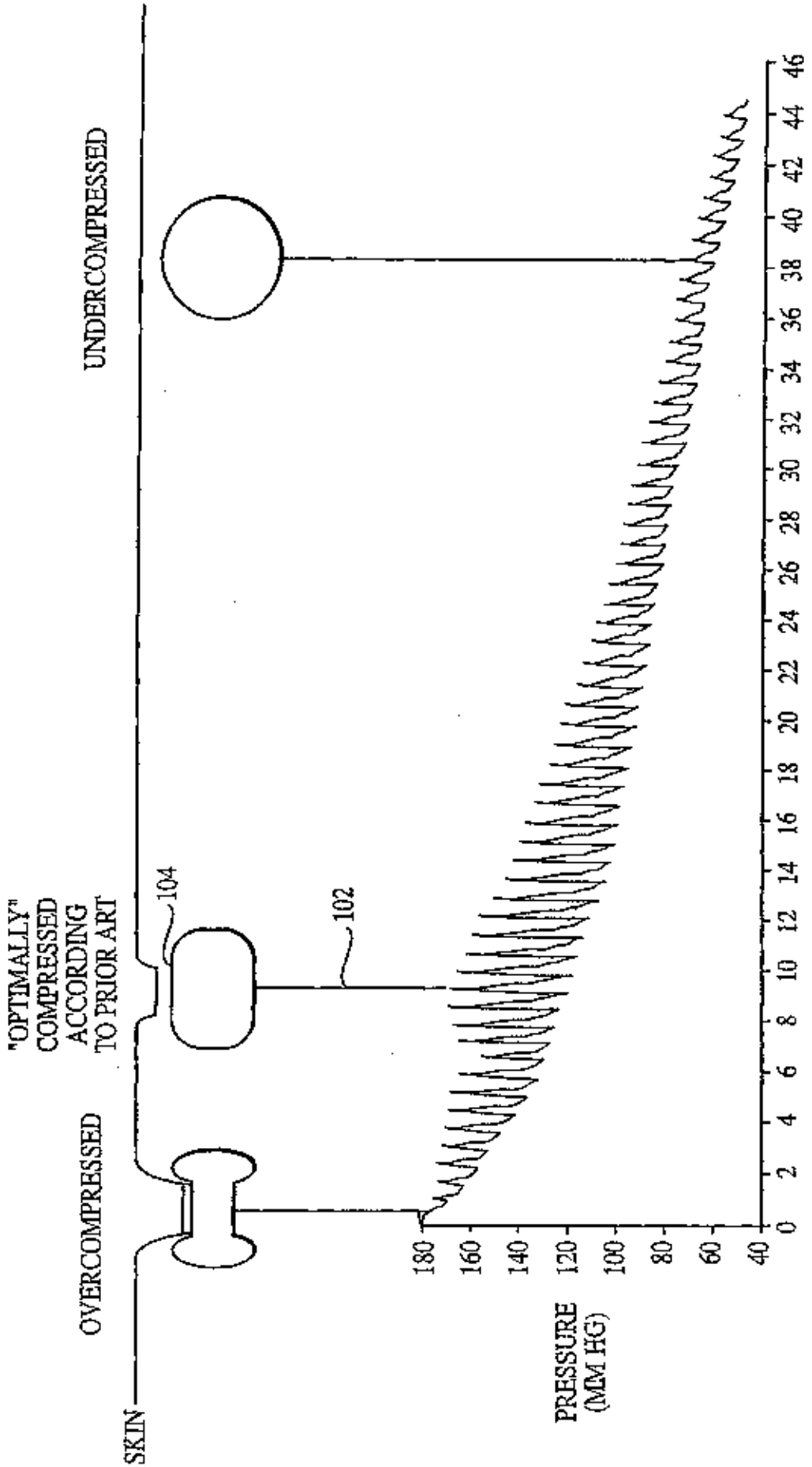


FIG. 1
PRIOR ART

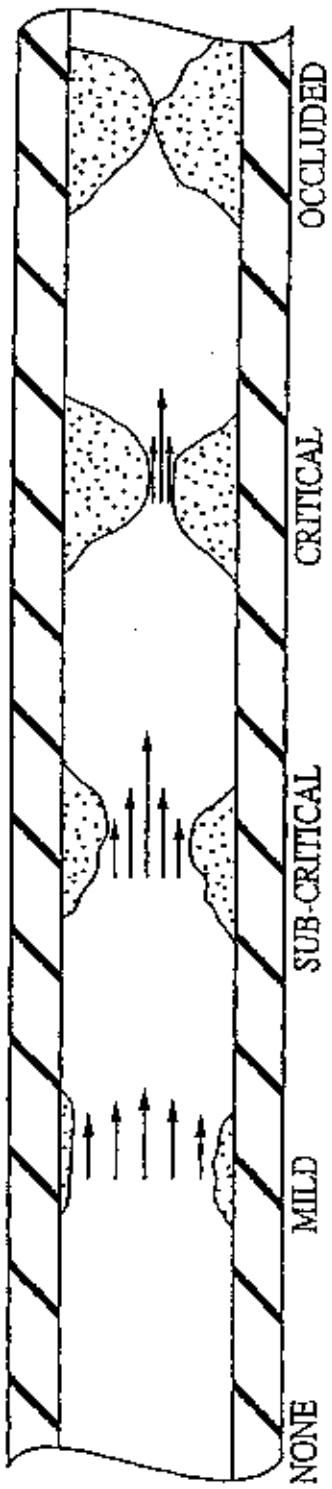


FIG. 2
PRIOR ART

24 JAN 2005

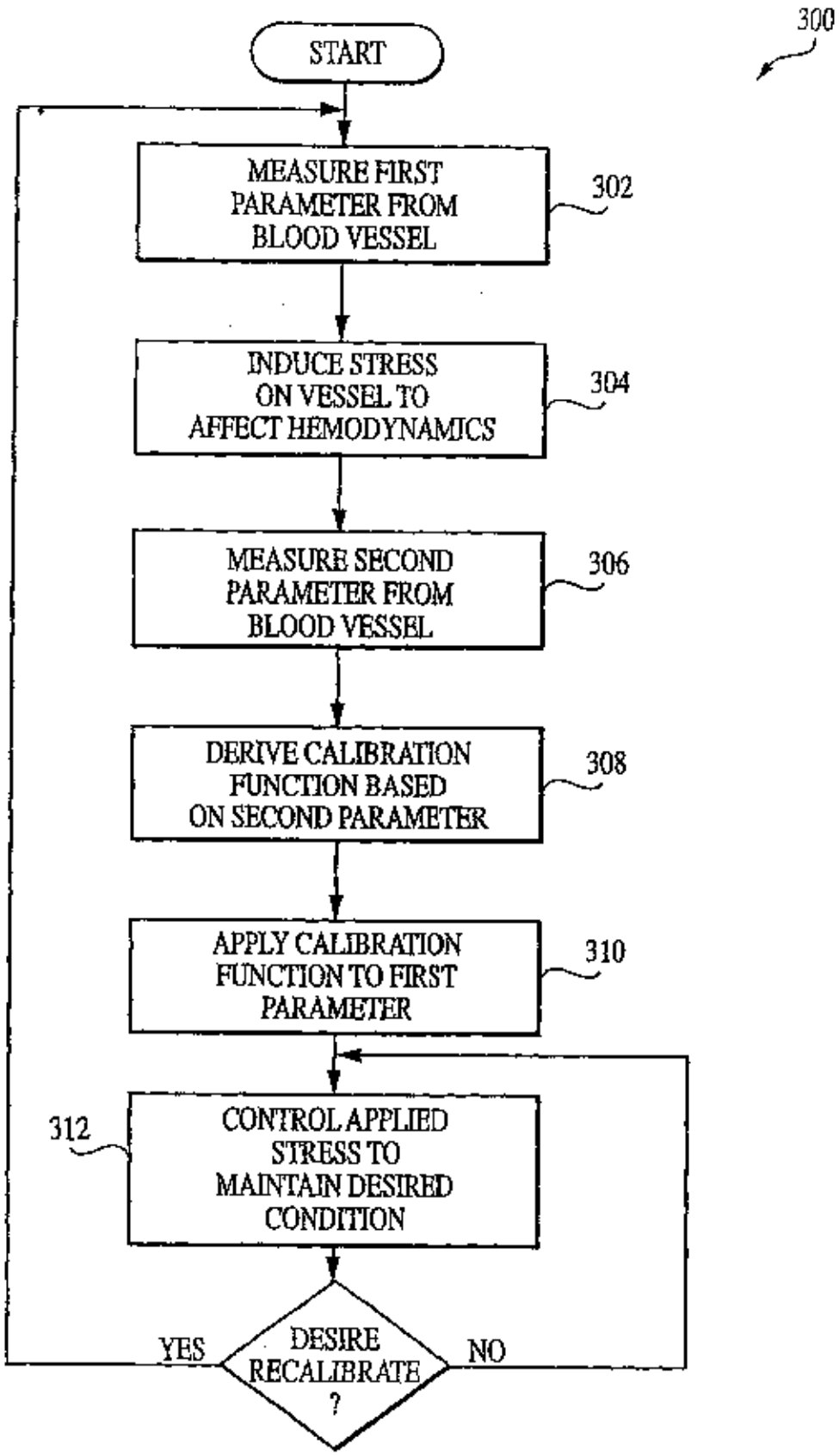


FIG. 3

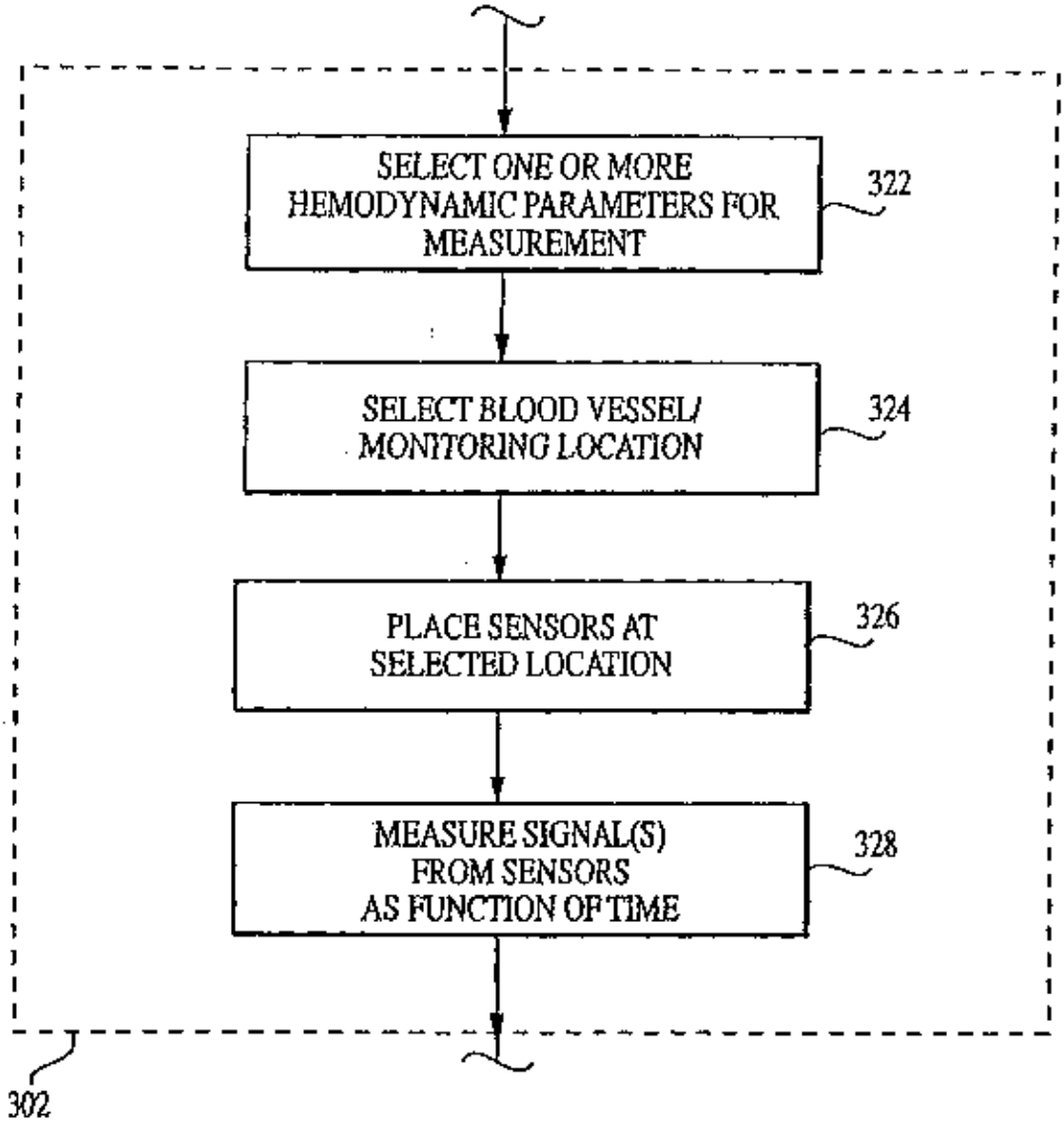

SELECT ONE OR MORE HEMODYNAMIC PARAMETERS FOR MEASUREMENT
322
SELECT BLOOD VESSEL/ MONITORING LOCATION
324
PLACE SENSORS AT SELECTED LOCATION
326
MEASURE SIGNAL(S) FROM SENSORS AS FUNCTION OF TIME
328
302

FIG. 3a

320

24 JAN 2005

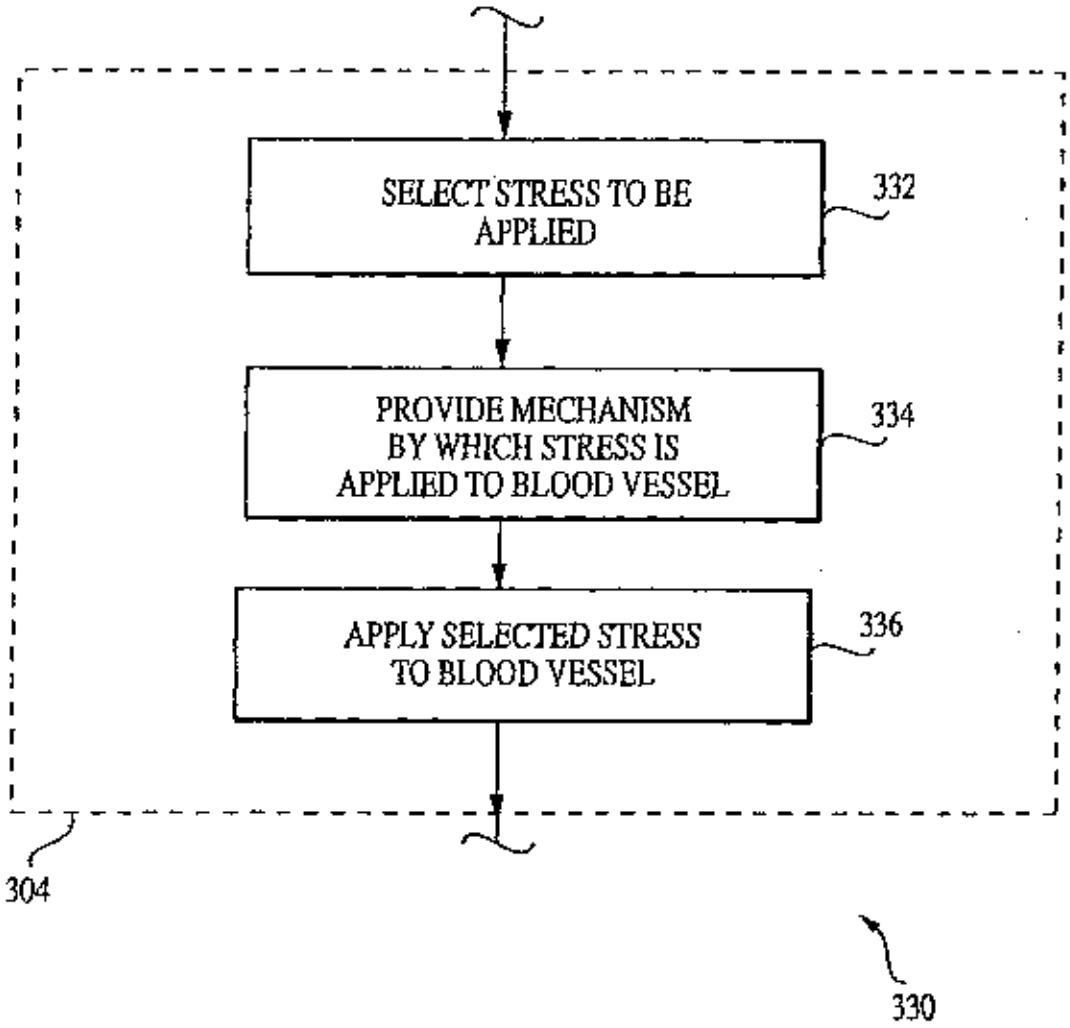


FIG. 3b

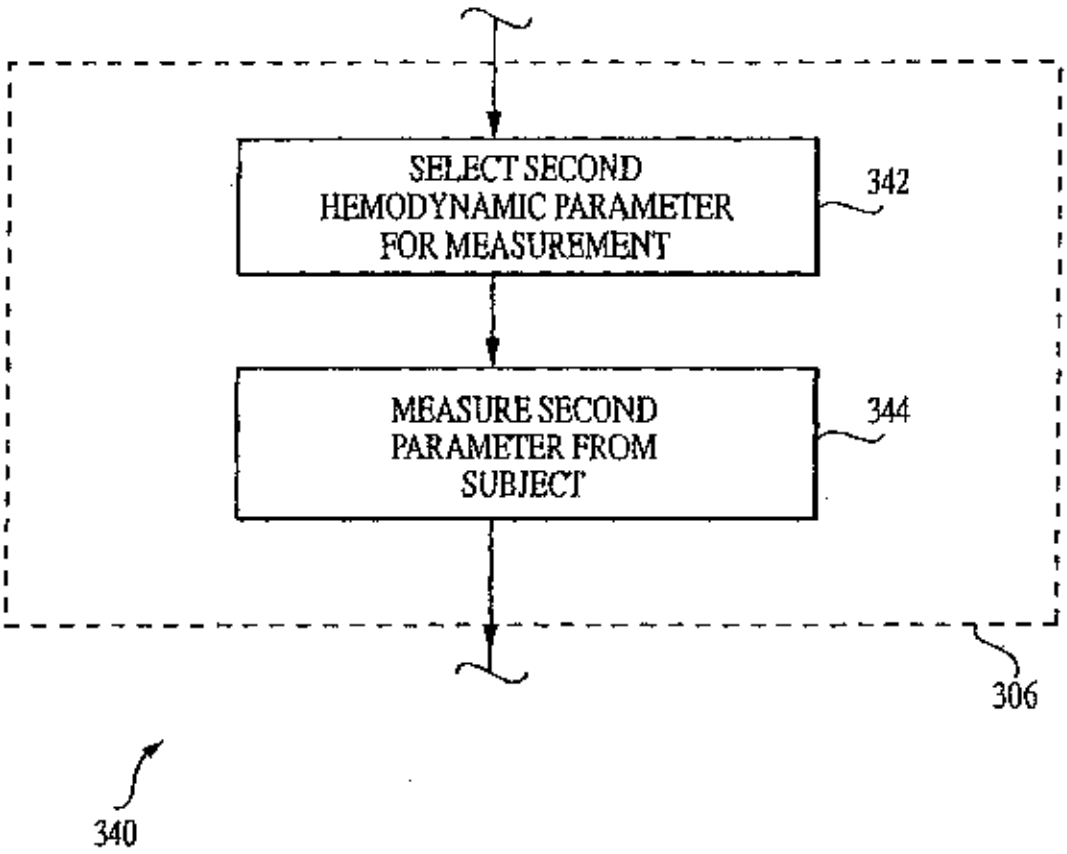

SELECT SECOND HEMODYNAMIC PARAMETER FOR MEASUREMENT
342
MEASURE SECOND PARAMETER FROM SUBJECT
344
306
340

FIG. 3c

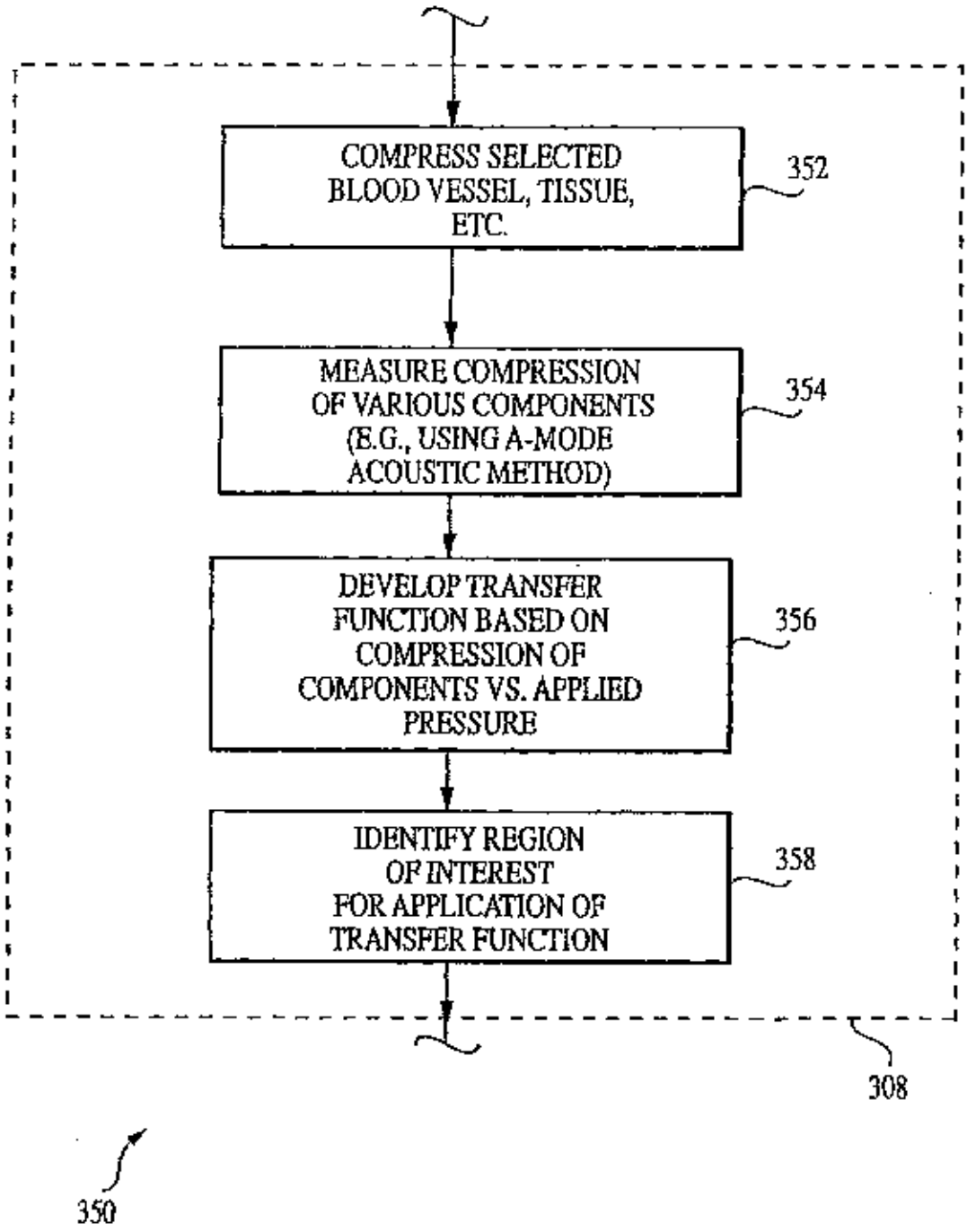

COMPRESS SELECTED BLOOD VESSEL, TISSUE, ETC.
352
MEASURE COMPRESSION OF VARIOUS COMPONENTS (E.G., USING A-MODE ACOUSTIC METHOD)
354
DEVELOP TRANSFER FUNCTION BASED ON COMPRESSION OF COMPONENTS VS. APPLIED PRESSURE
356
IDENTIFY REGION OF INTEREST FOR APPLICATION OF TRANSFER FUNCTION
358
308
350

FIG. 3d

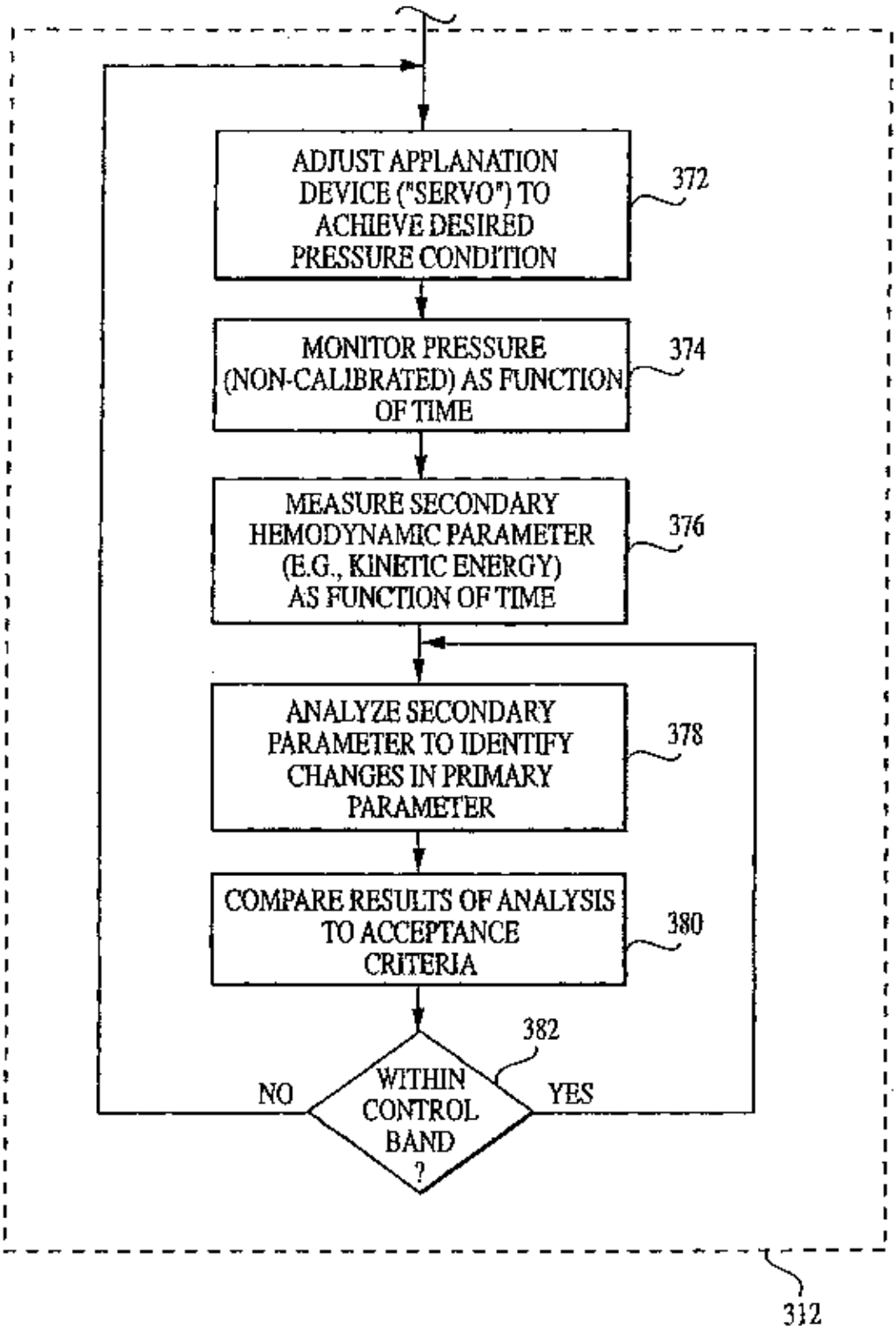

ADJUST APPLANATION DEVICE ("SERVO") TO ACHIEVE DESIRED PRESSURE CONDITION
372
MONITOR PRESSURE (NON-CALIBRATED) AS FUNCTION OF TIME
374
MEASURE SECONDARY HEMODYNAMIC PARAMETER (E.G., KINETIC ENERGY) AS FUNCTION OF TIME
376
ANALYZE SECONDARY PARAMETER TO IDENTIFY CHANGES IN PRIMARY PARAMETER
378
COMPARE RESULTS OF ANALYSIS TO ACCEPTANCE CRITERIA
380
382
WITHIN CONTROL BAND ?
NO
YES
312

FIG. 3e

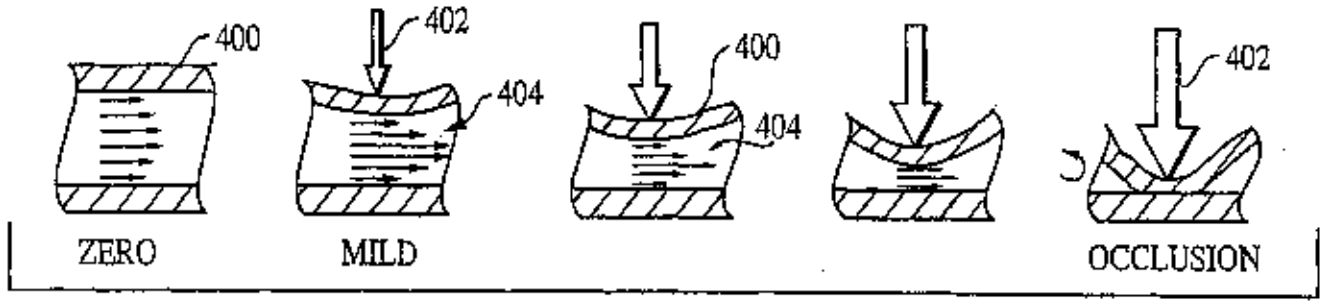


FIG. 4a

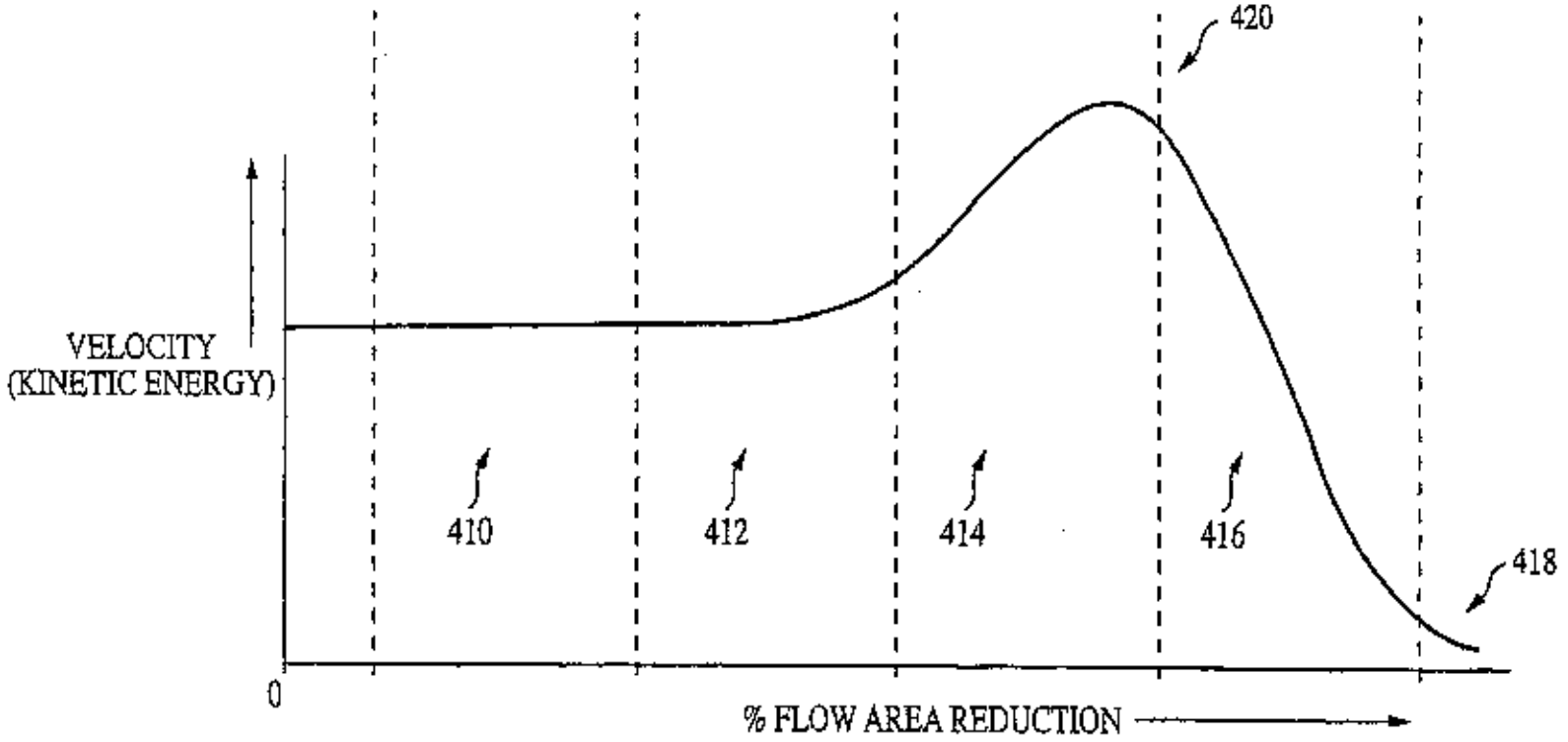


FIG. 4b

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FIG. 5a



FIG. 5b

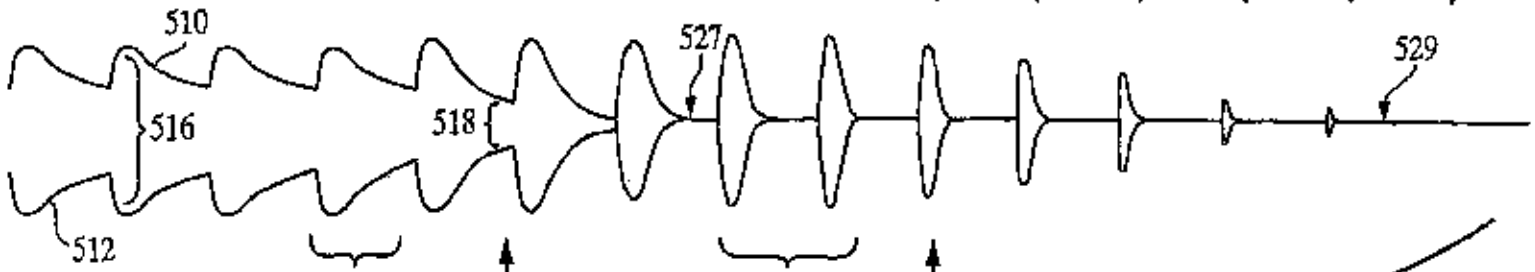
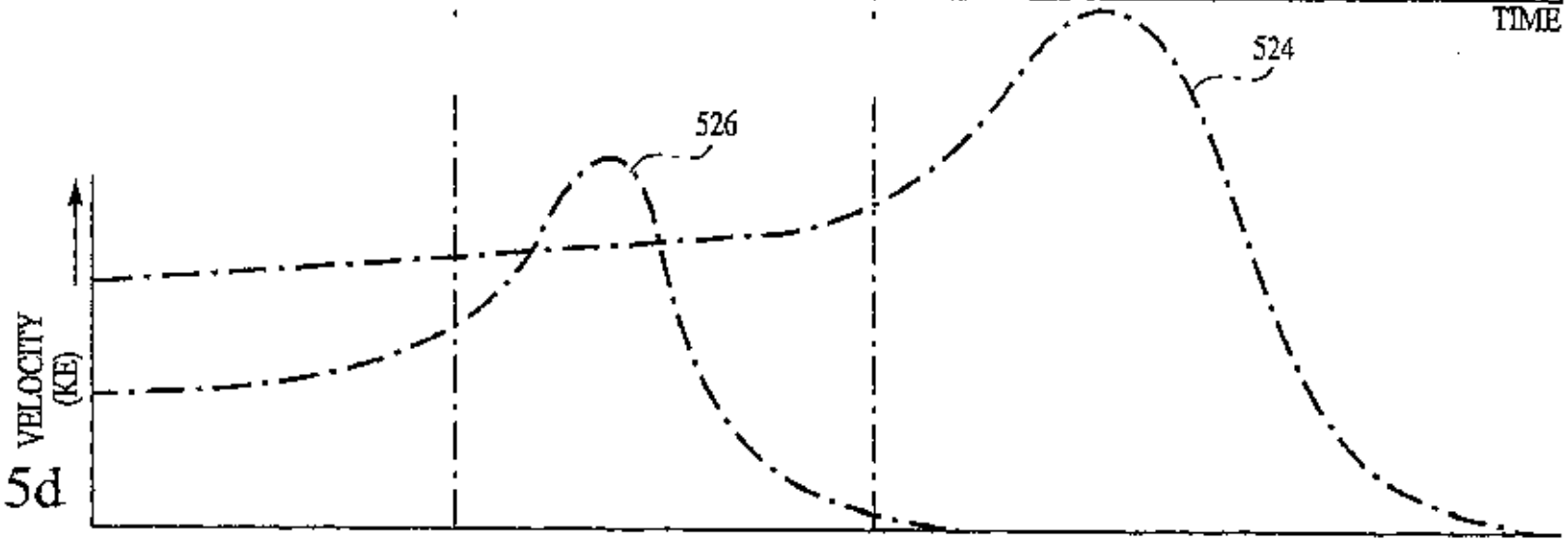


FIG. 5c

FIG. 5d



24 JAN 2005

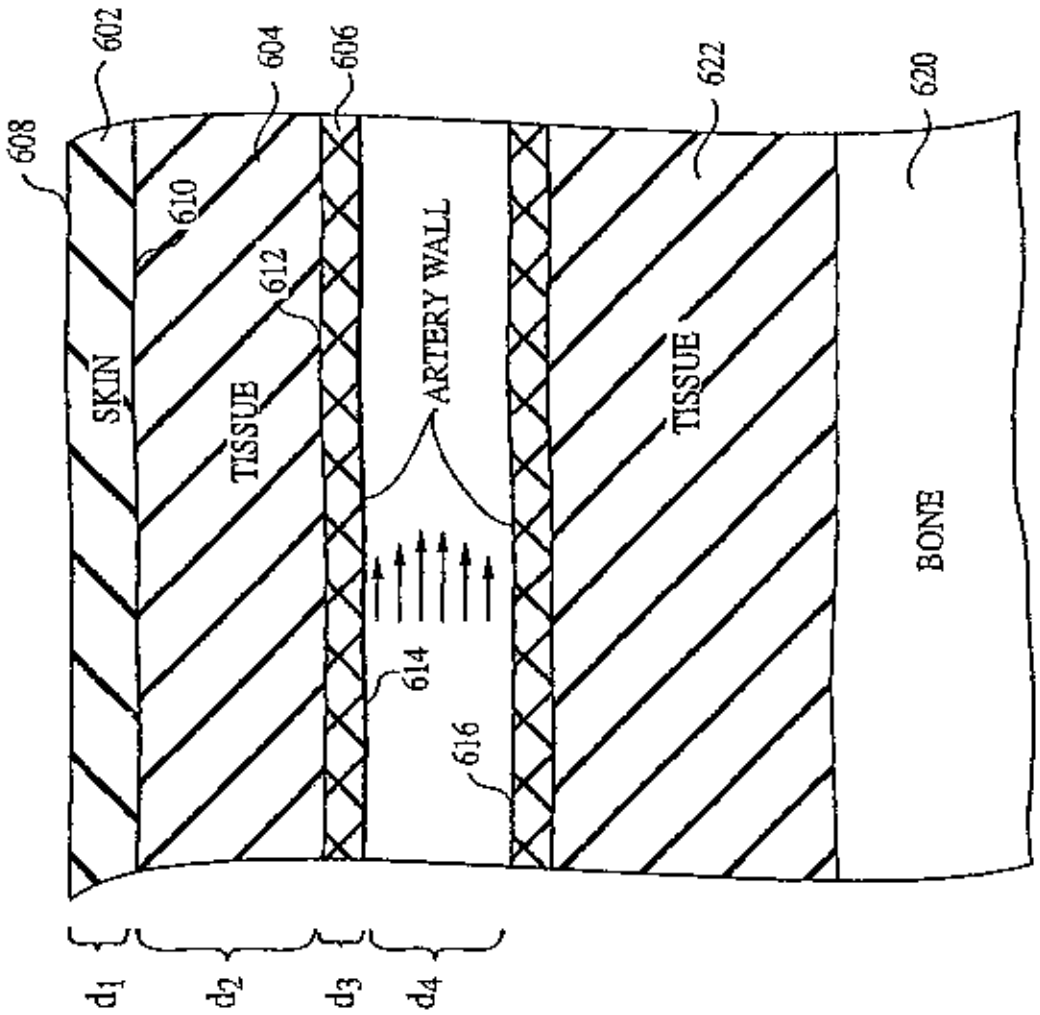

602
604
606
608
610
612
622
620
SKIN
TISSUE
ARTERY WALL
TISSUE
BONE
614
616
d1
d2
d3
d4

FIG. 6

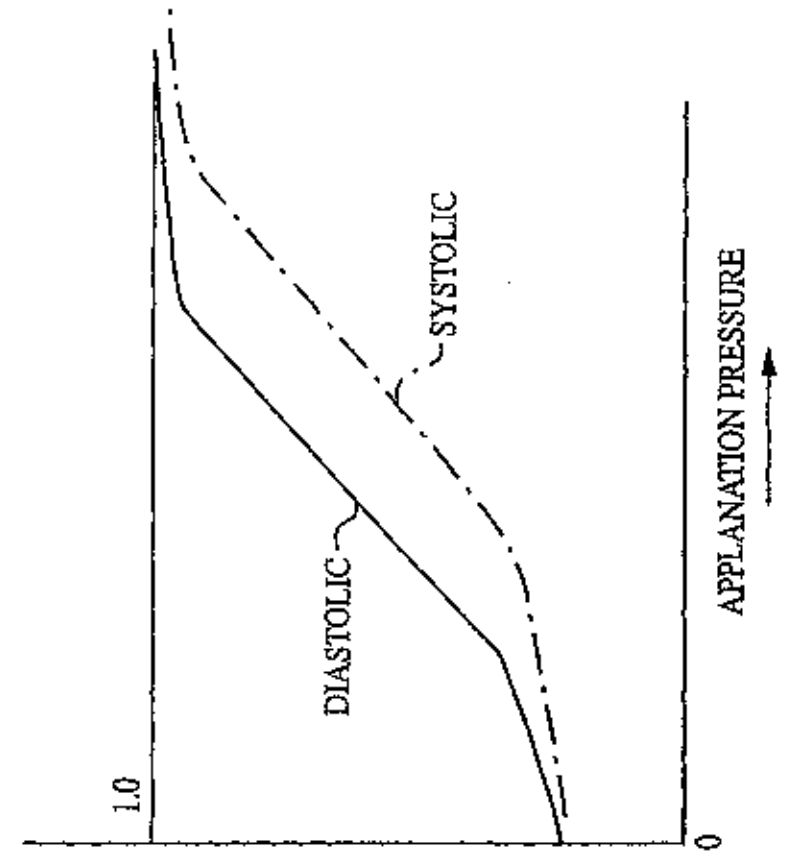

1.0
DIASTOLIC
SYSTOLIC
0
APPLANATION PRESSURE
TRANSFER FRACTION

FIG. 7b

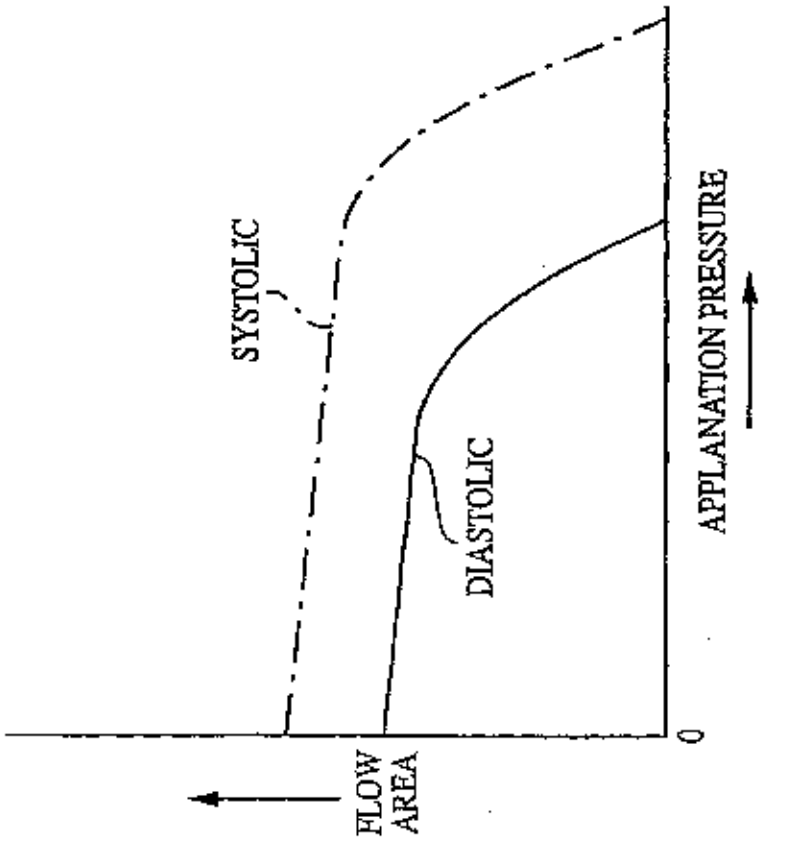

SYSTOLIC
DIASTOLIC
0
APPLANATION PRESSURE
FLOW AREA

FIG. 7a

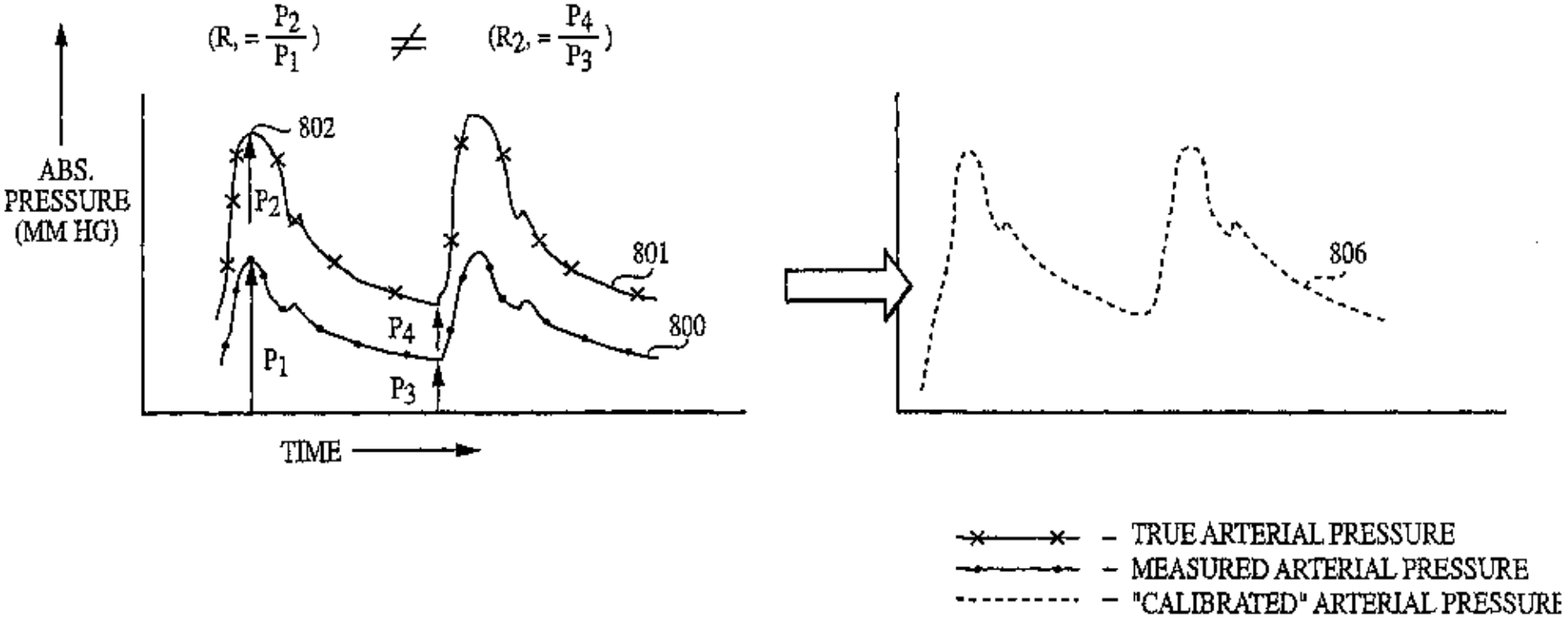


FIG. 8

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24 JAN 2005

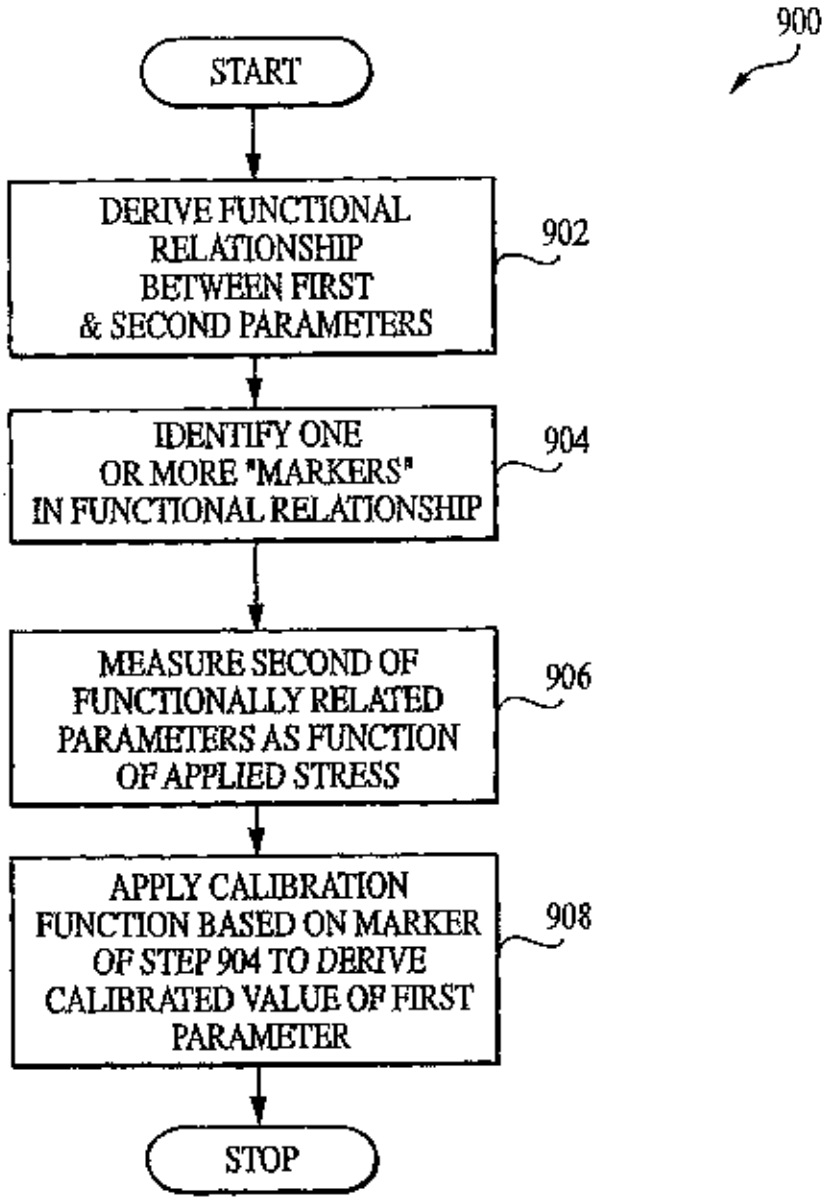


FIG. 9

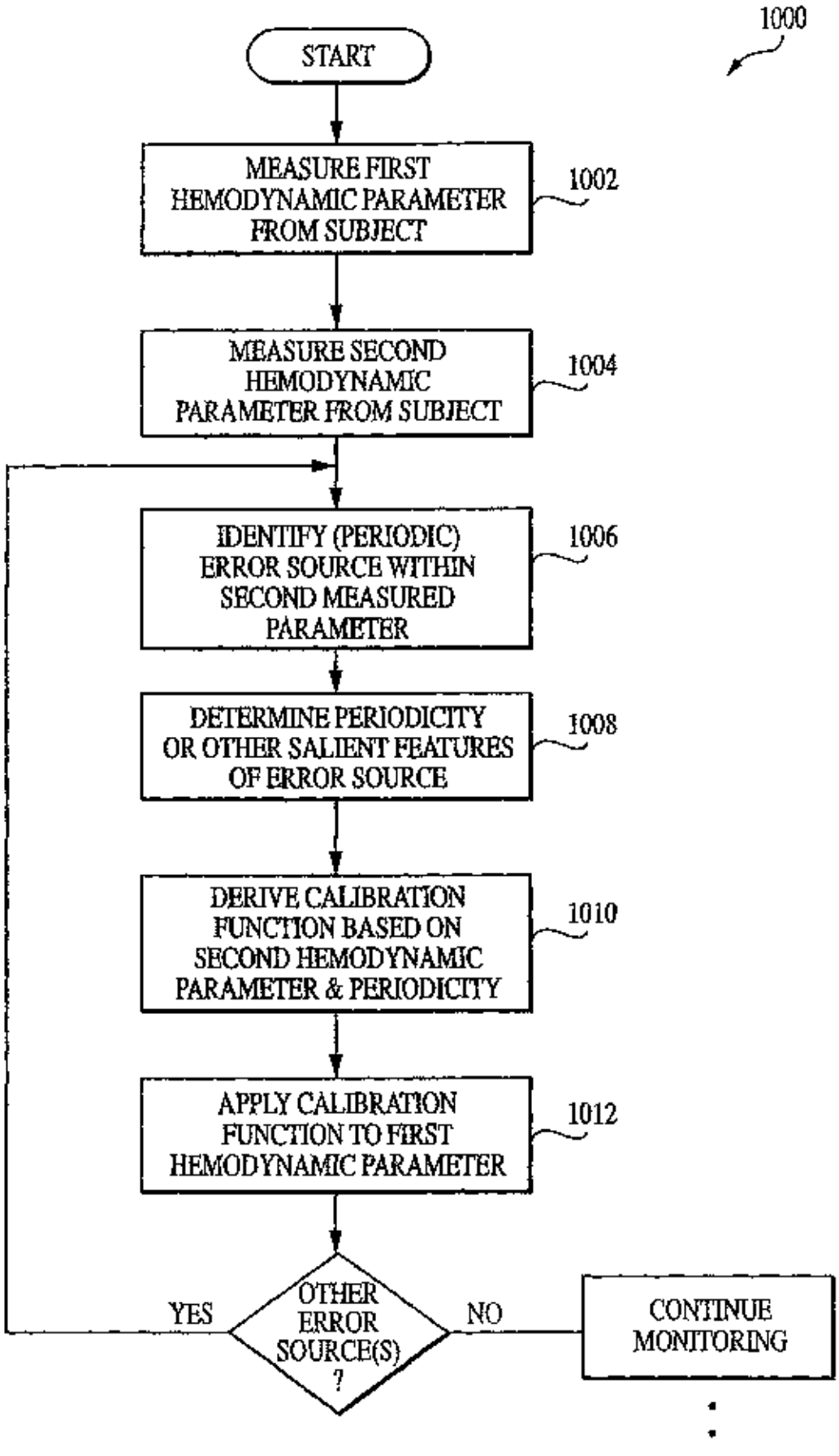

1000
START
MEASURE FIRST HEMODYNAMIC PARAMETER FROM SUBJECT
1002
MEASURE SECOND HEMODYNAMIC PARAMETER FROM SUBJECT
1004
IDENTIFY (PERIODIC) ERROR SOURCE WITHIN SECOND MEASURED PARAMETER
1006
DETERMINE PERIODICITY OR OTHER SALIENT FEATURES OF ERROR SOURCE
1008
DERIVE CALIBRATION FUNCTION BASED ON SECOND HEMODYNAMIC PARAMETER & PERIODICITY
1010
APPLY CALIBRATION FUNCTION TO FIRST HEMODYNAMIC PARAMETER
1012
OTHER ERROR SOURCE(S) ?
YES
NO
CONTINUE MONITORING

FIG. 10

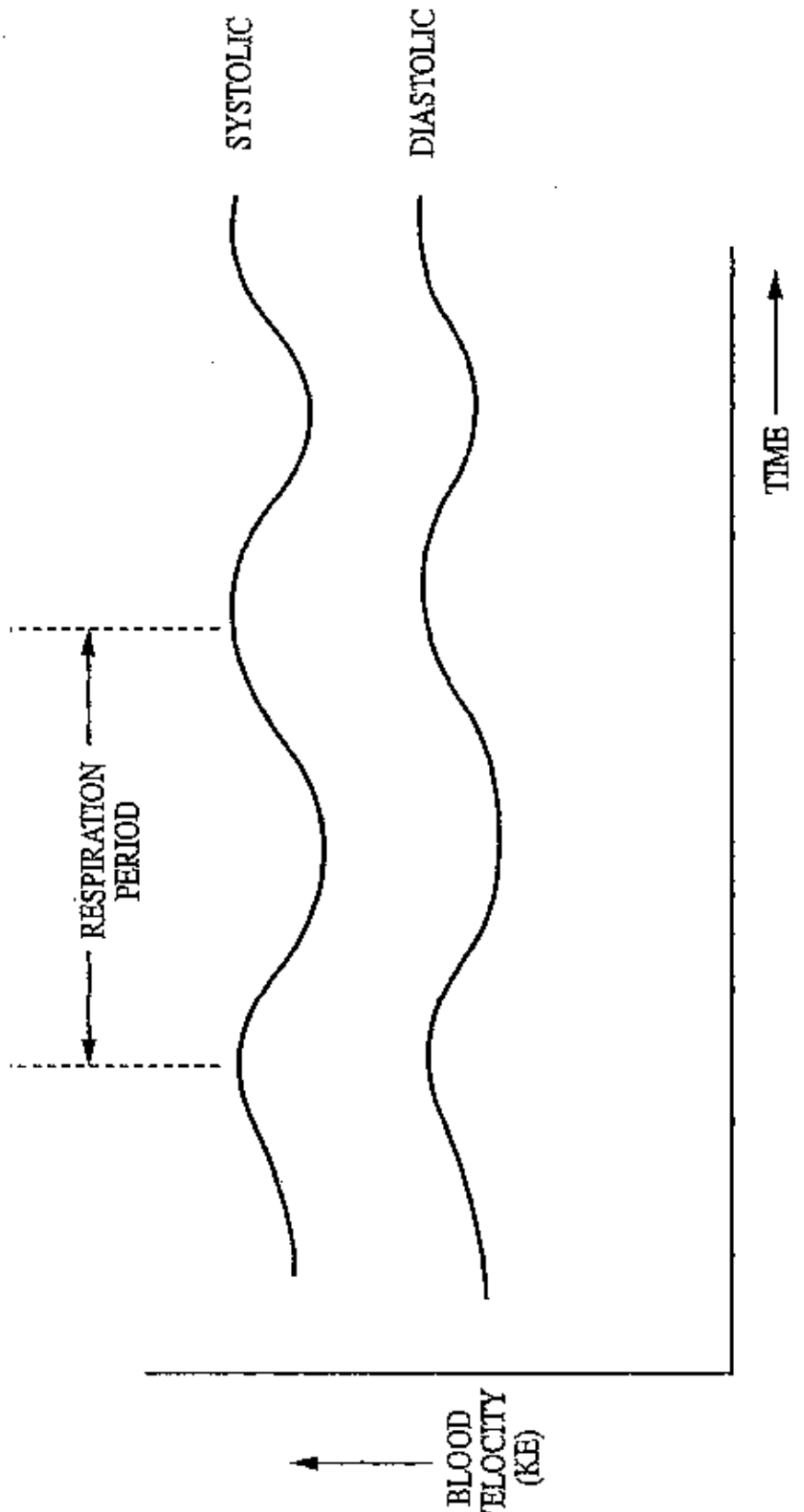

SYSTOLIC
DIASTOLIC
RESPIRATION PERIOD
TIME
BLOOD VELOCITY (KE)

FIG. 11

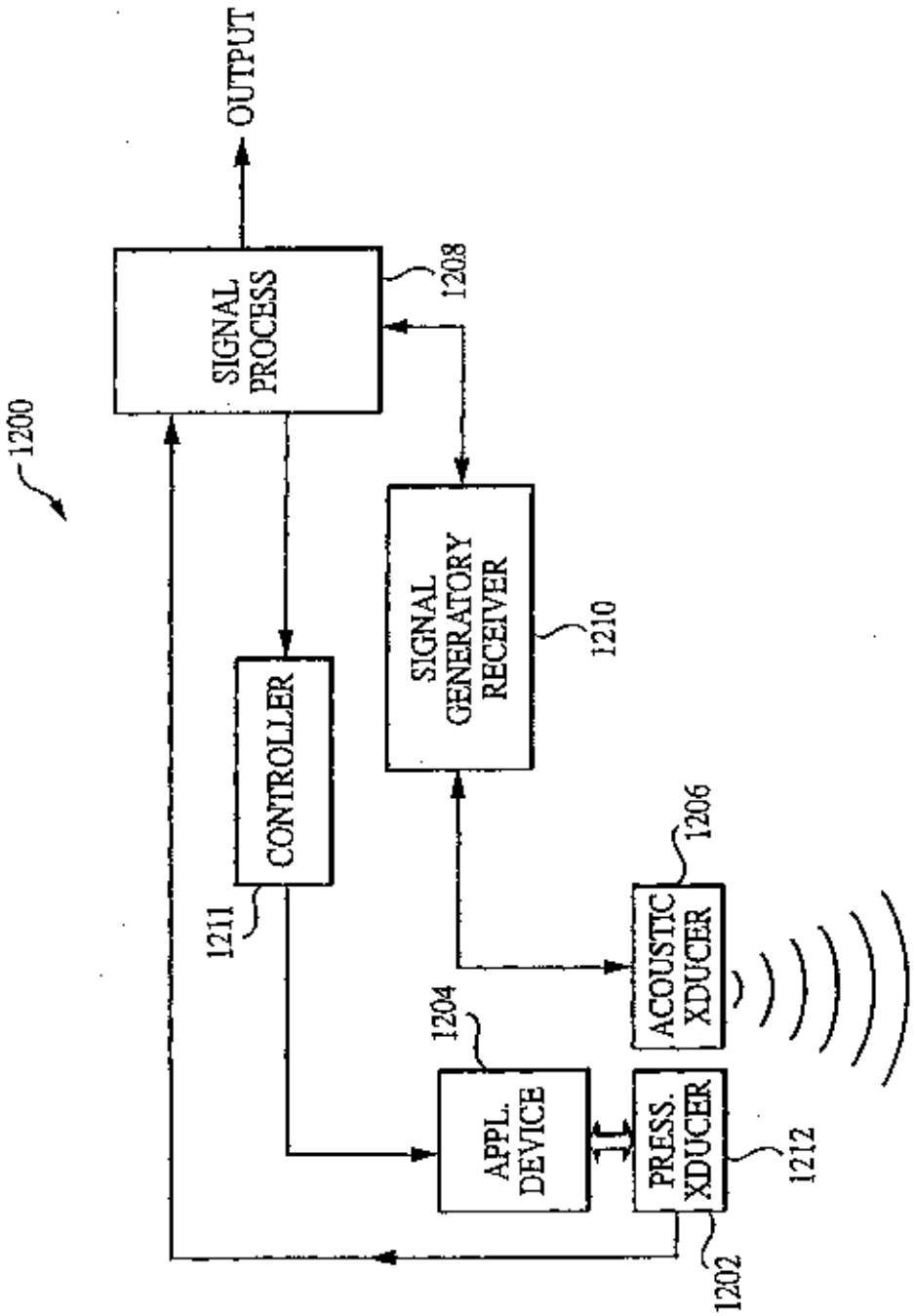

1200
OUTPUT
SIGNAL PROCESS
1208
SIGNAL GENERATORY RECEIVER
1210
CONTROLLER
1211
1206
ACOUSTIC XDUCER
1204
APPL. DEVICE
PRESS. XDUCER
1212
1202

FIG. 12

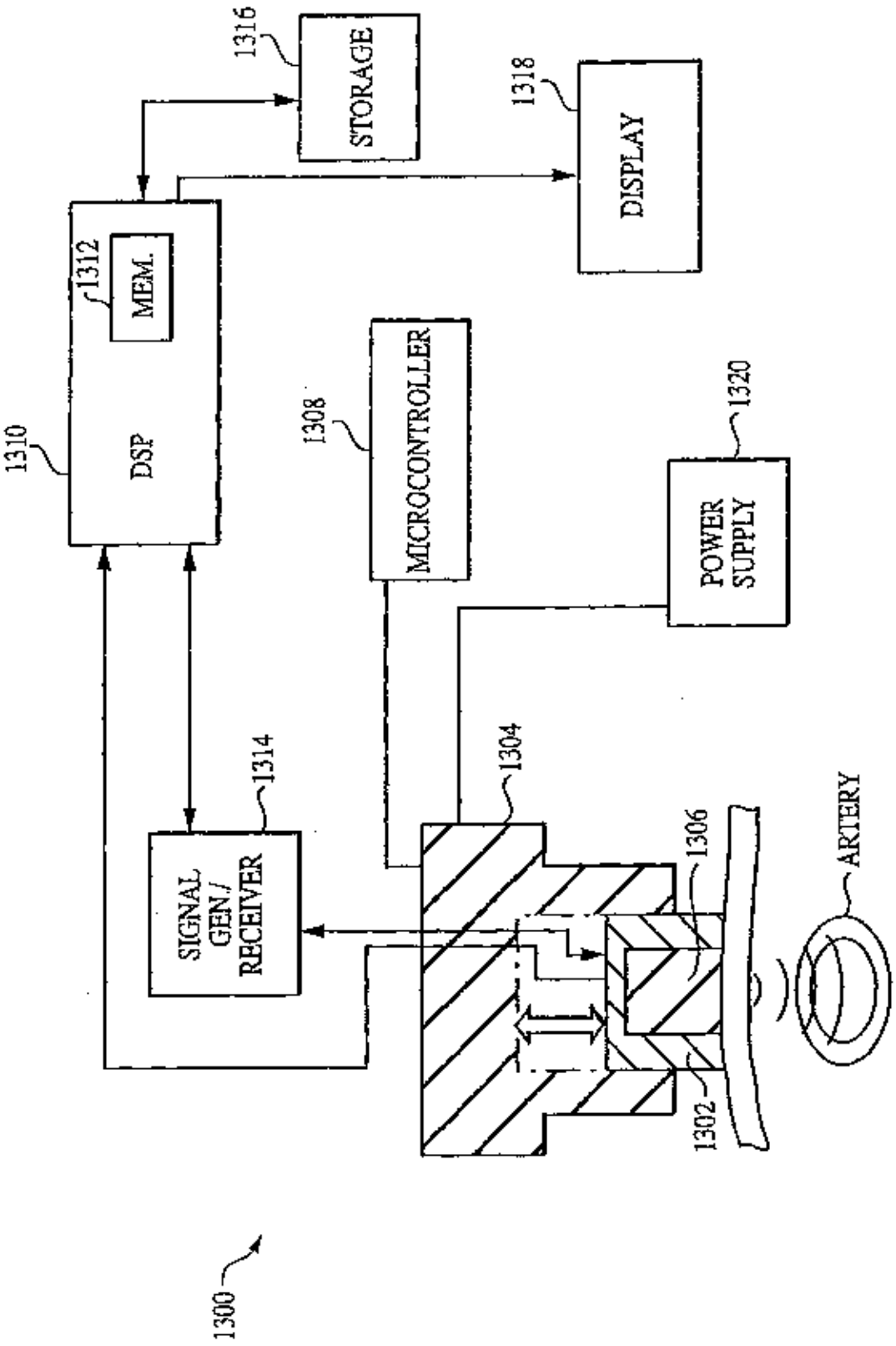

1300
1310
DSP
1312
MEM.
1316
STORAGE
1318
DISPLAY
1308
MICROCONTROLLER
1320
POWER SUPPLY
1314
SIGNAL GEN./ RECEIVER
1304
1306
1302
ARTERY

FIG. 13

24 JAN 2005

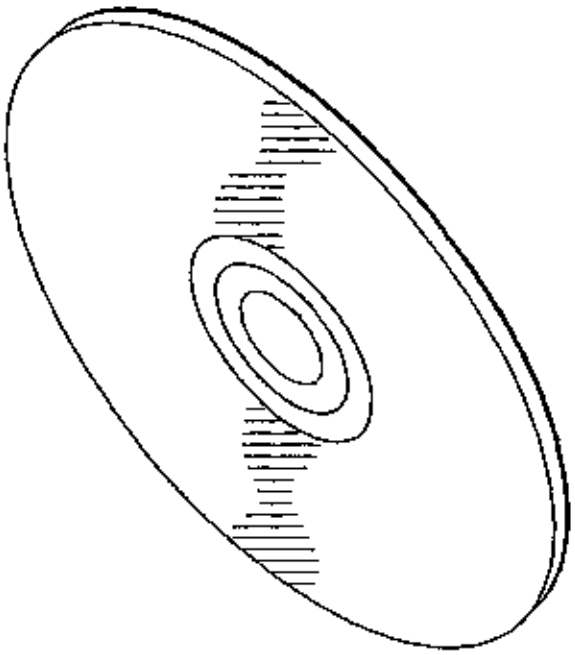


FIG. 14b

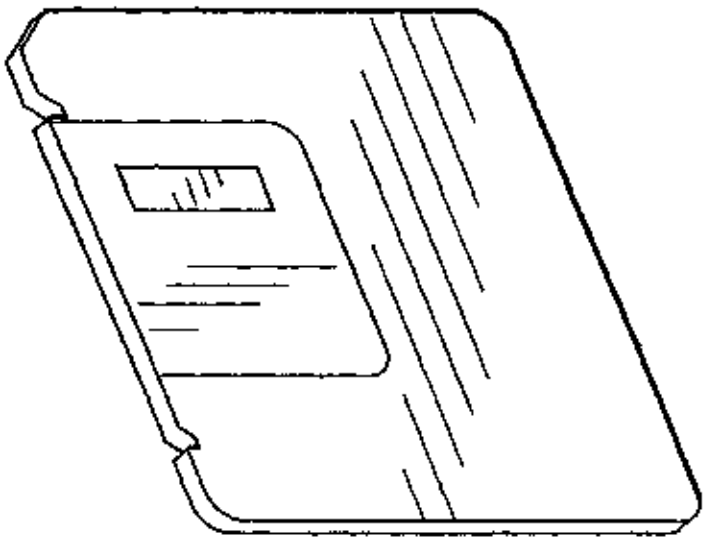


FIG. 14a

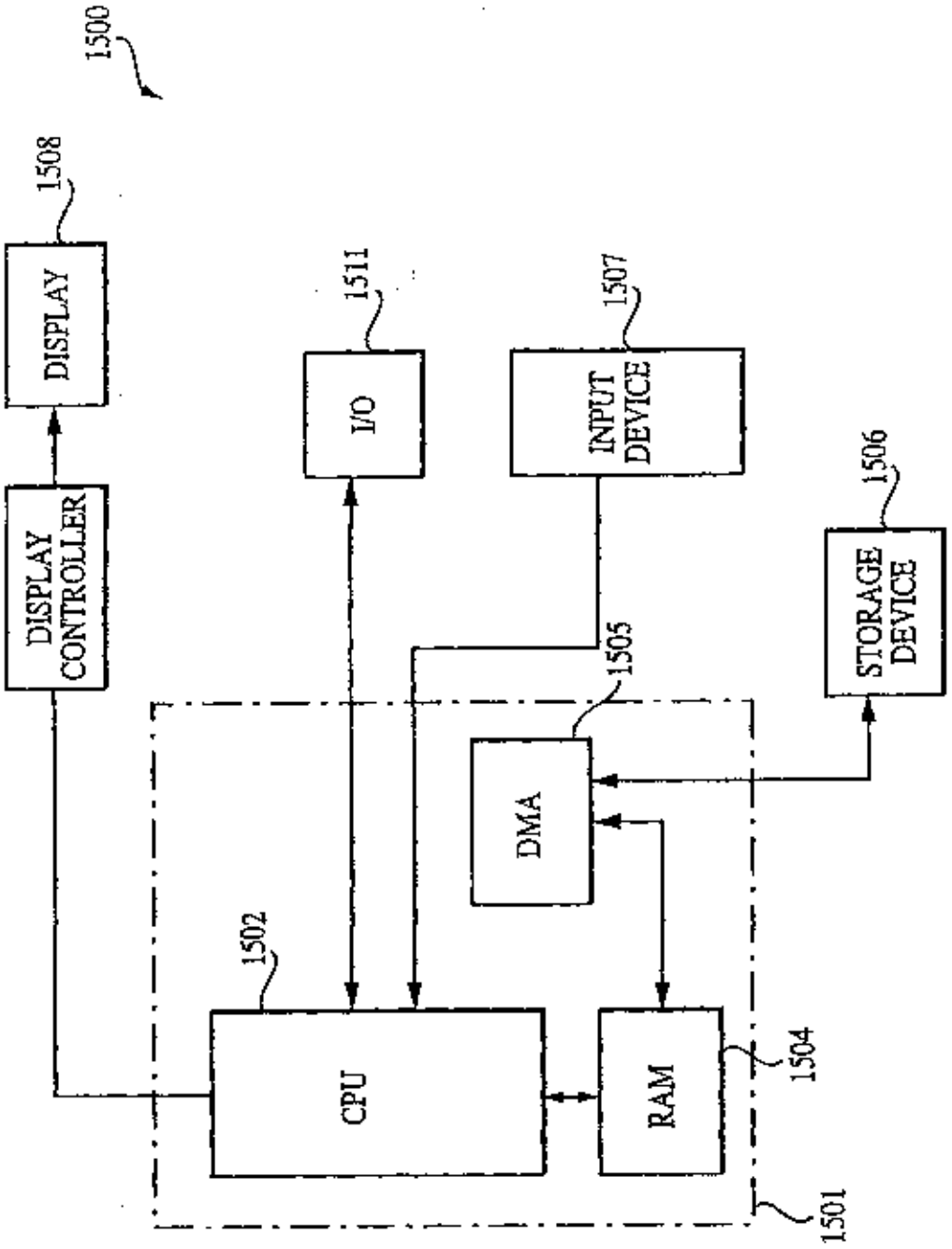

1500
1508
DISPLAY
DISPLAY CONTROLLER
1511
I/O
1507
INPUT DEVICE
1506
STORAGE DEVICE
1505
DMA
1502
CPU
RAM
1504
1501

FIG. 15

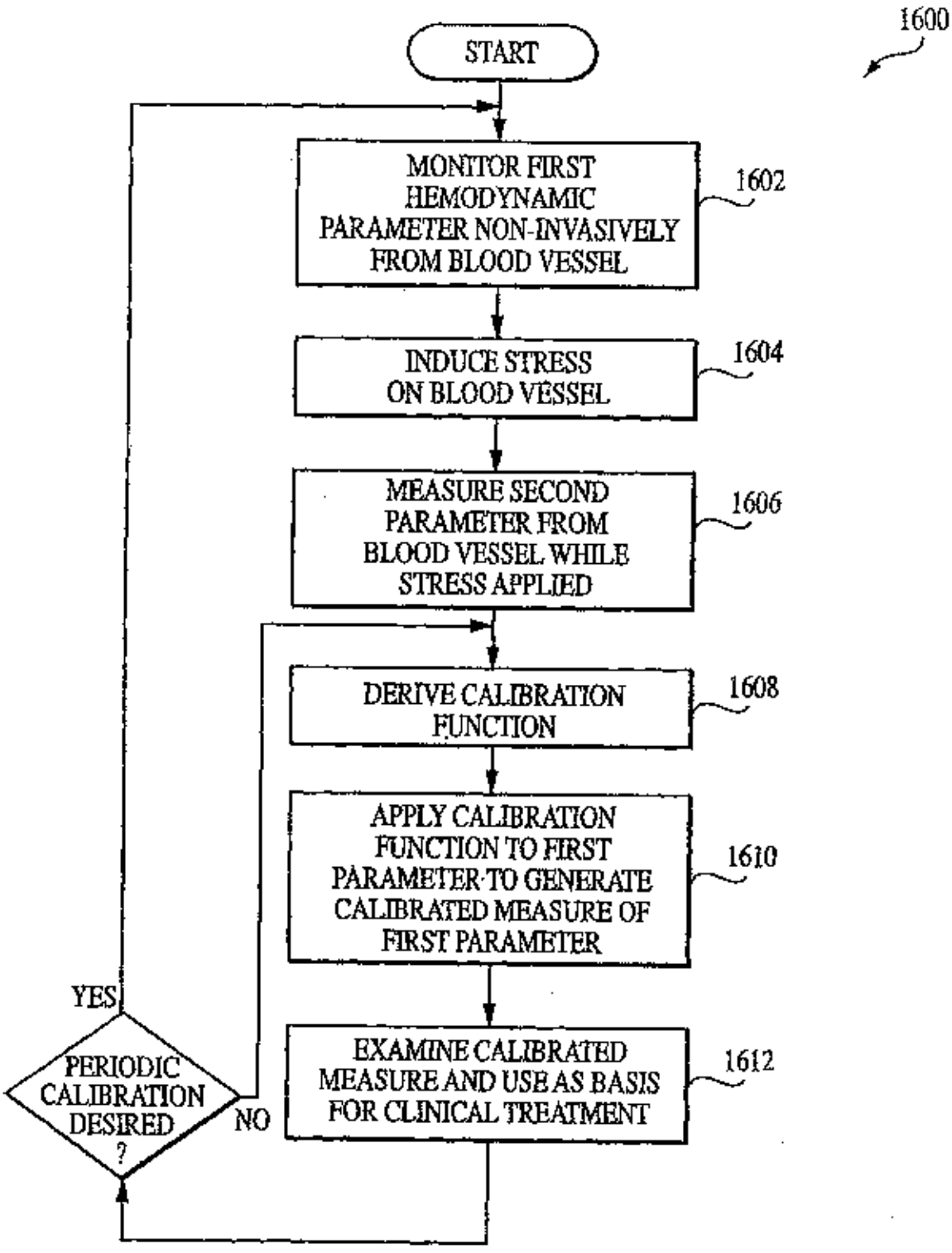

1600
START
MONITOR FIRST HEMODYNAMIC PARAMETER NON-INVASIVELY FROM BLOOD VESSEL
1602
INDUCE STRESS ON BLOOD VESSEL
1604
MEASURE SECOND PARAMETER FROM BLOOD VESSEL WHILE STRESS APPLIED
1606
DERIVE CALIBRATION FUNCTION
1608
APPLY CALIBRATION FUNCTION TO FIRST PARAMETER TO GENERATE CALIBRATED MEASURE OF FIRST PARAMETER
1610
EXAMINE CALIBRATED MEASURE AND USE AS BASIS FOR CLINICAL TREATMENT
1612
PERIODIC CALIBRATION DESIRED ?
YES
NO

FIG. 16

24 JAN 2005

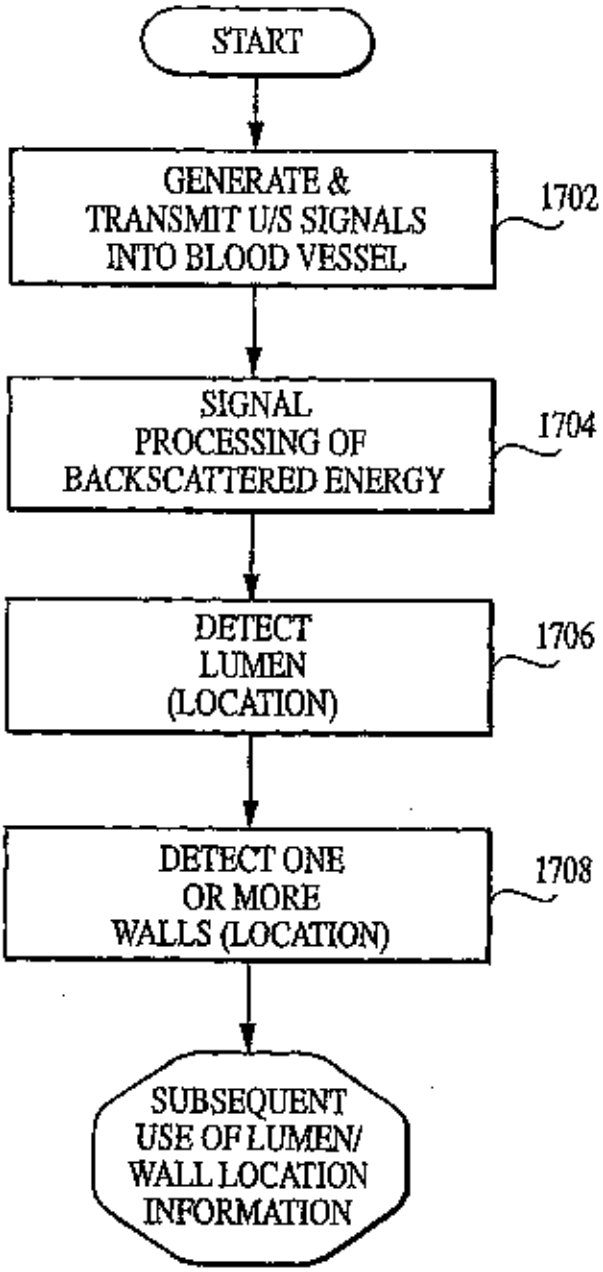


FIG. 17

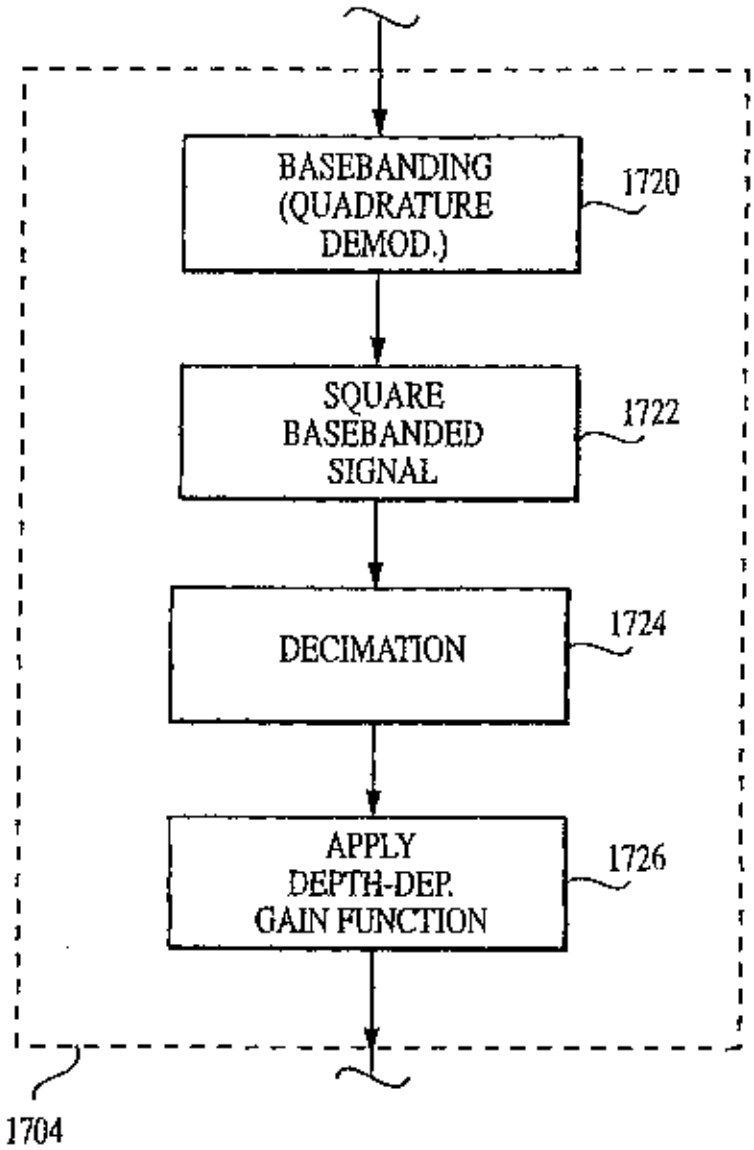

BASEBANDING (QUADRATURE DEMOD.)
1720
SQUARE BASEBANDED SIGNAL
1722
DECIMATION
1724
APPLY DEPTH-DEP. GAIN FUNCTION
1726
1704

FIG. 17a

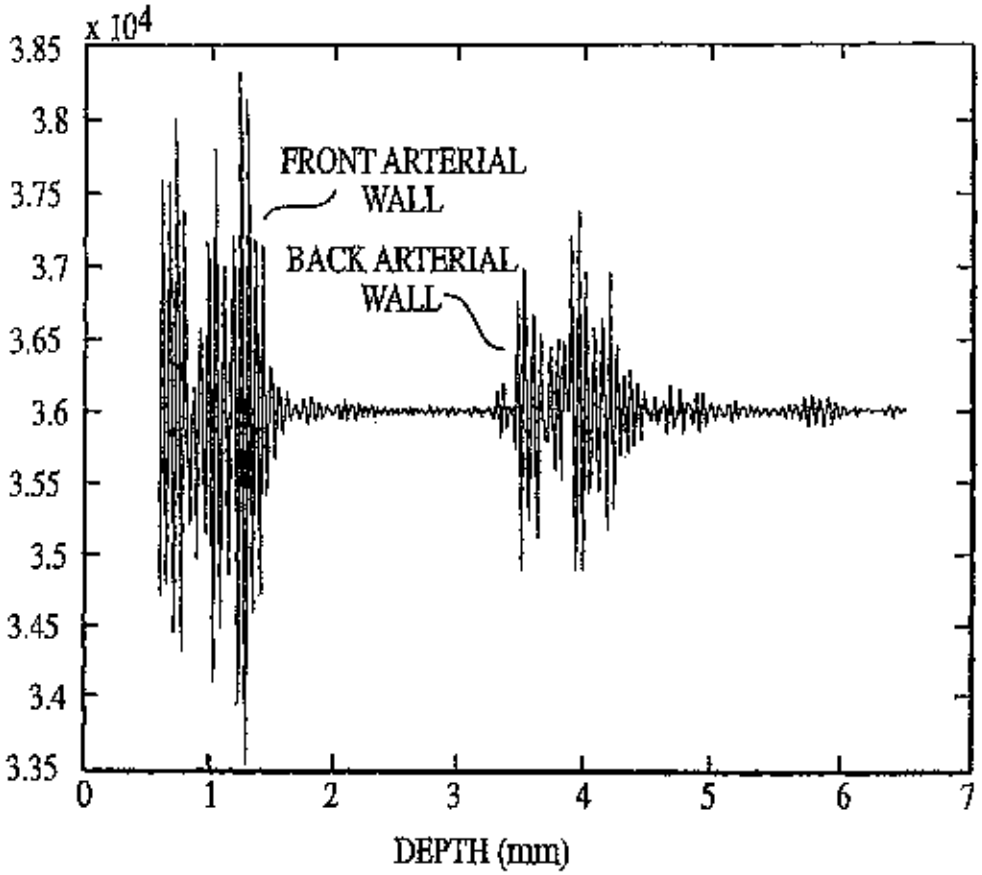

x 10^4
3.85
3.8
3.75
3.7
3.65
3.6
3.55
3.5
3.45
3.4
3.35
FRONT ARTERIAL WALL
BACK ARTERIAL WALL
0
1
2
3
4
5
6
7
DEPTH (mm)

FIG. 18

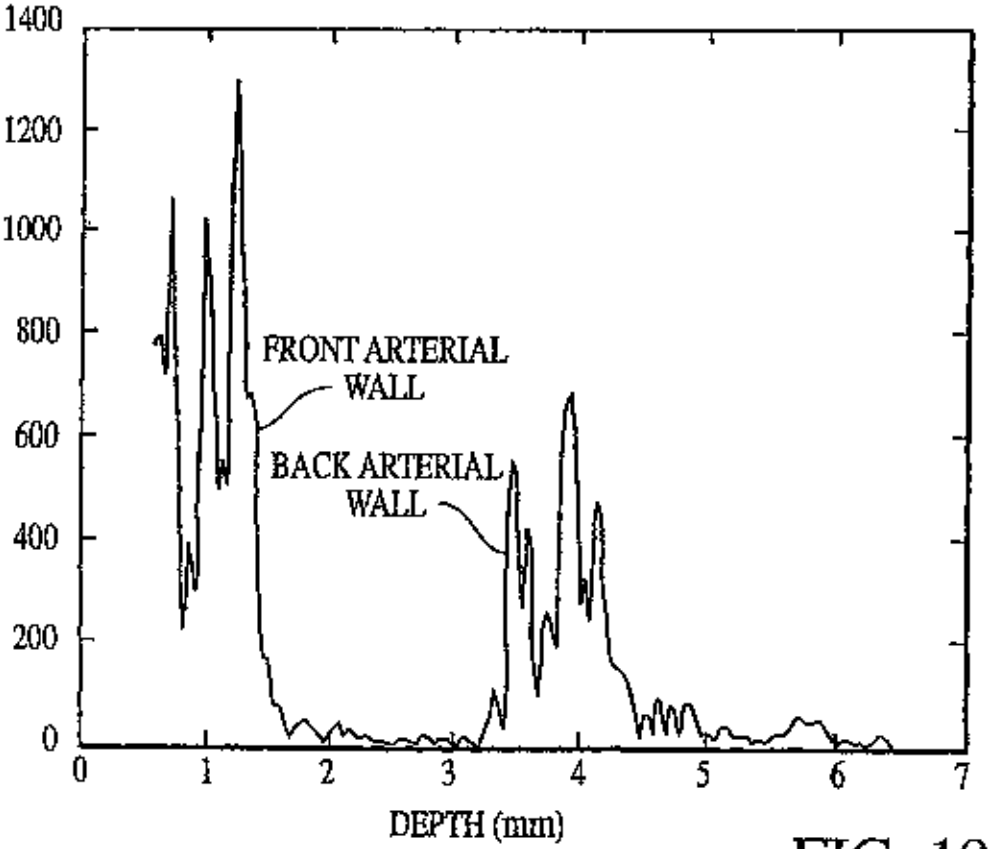

1400
1200
1000
800
600
400
200
0
FRONT ARTERIAL WALL
BACK ARTERIAL WALL
0
1
2
3
4
5
6
7
DEPTH (mm)

FIG. 19

24 JAN 2005

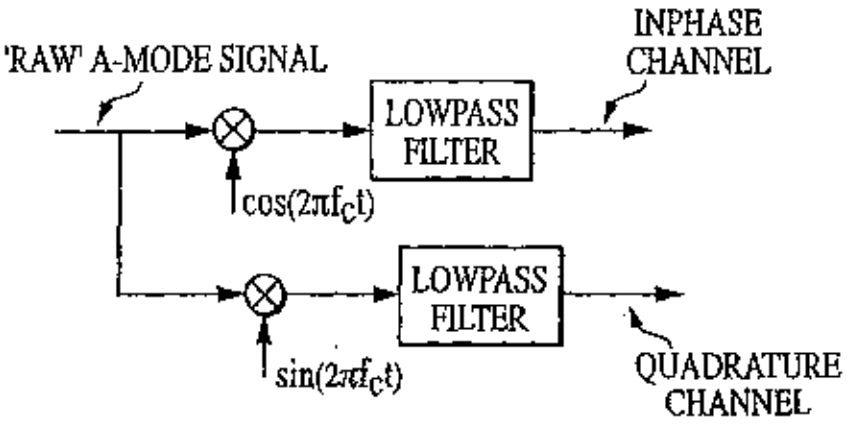


FIG. 21

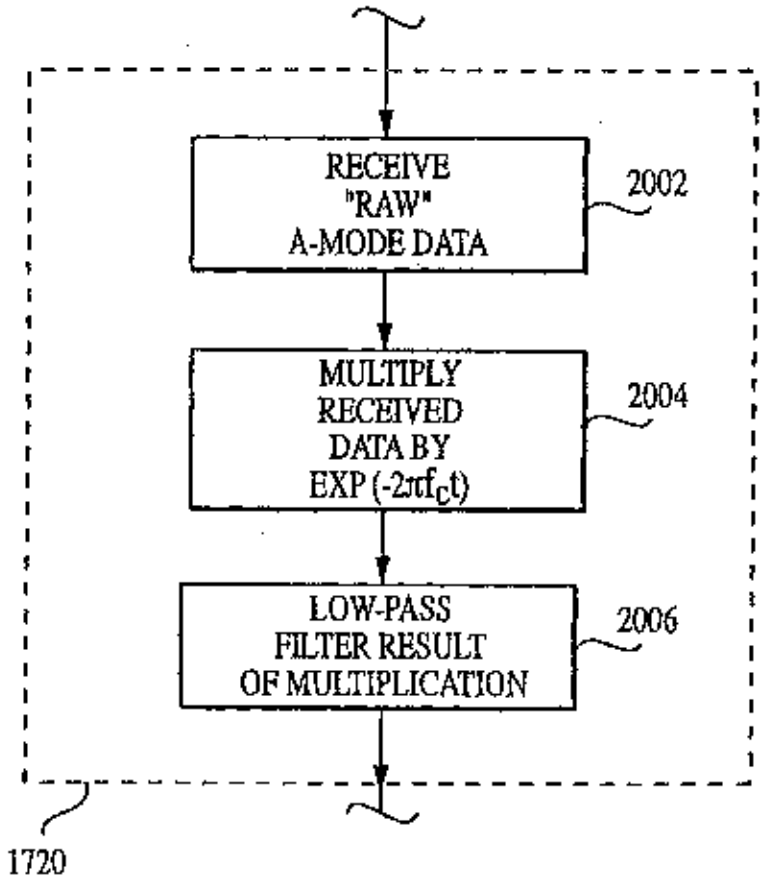


FIG. 20

24 JAN 2005

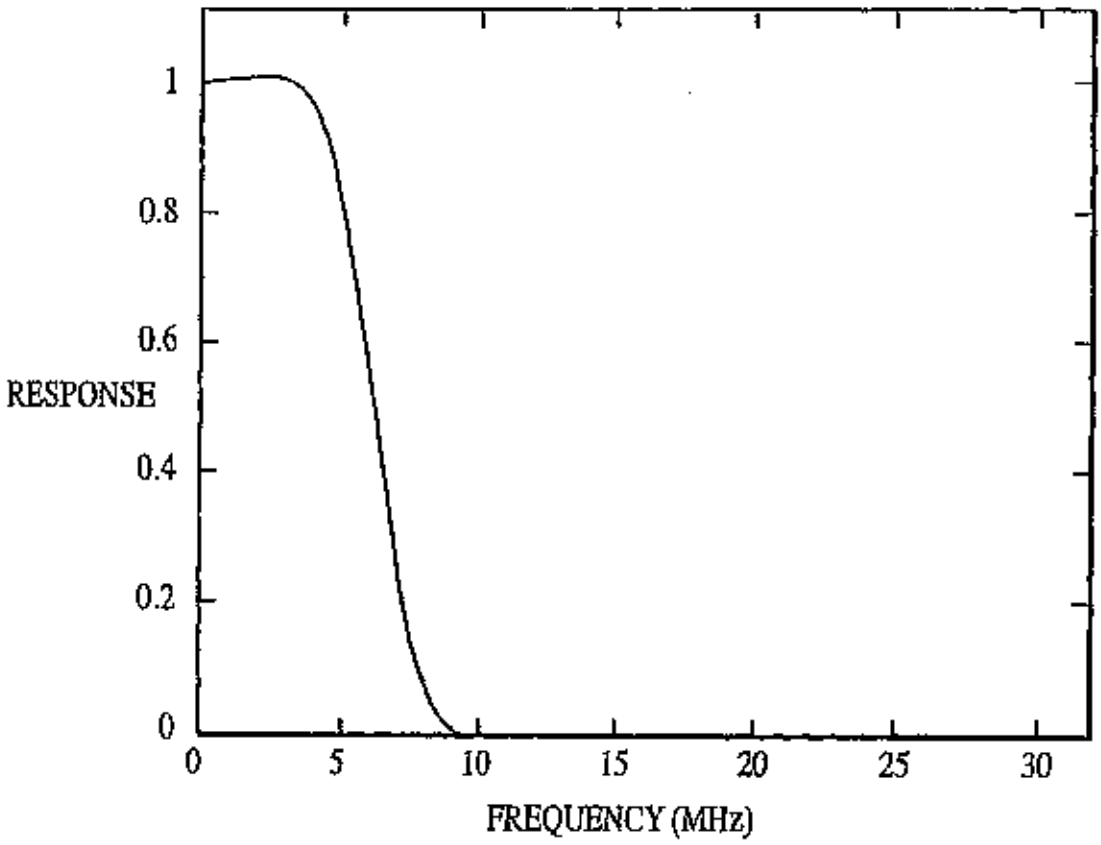


FIG. 22

24 JAN 2005

-1
-1
0
2
4
6
6
2
-6
-16
-25
-26
-16
10
50
98
143
176
188
176
143
98
50
10
-16
-26
-25
-16
-6
6
6
6
4
2
0
-1
-1

FIG. 23

24 JAN 2005

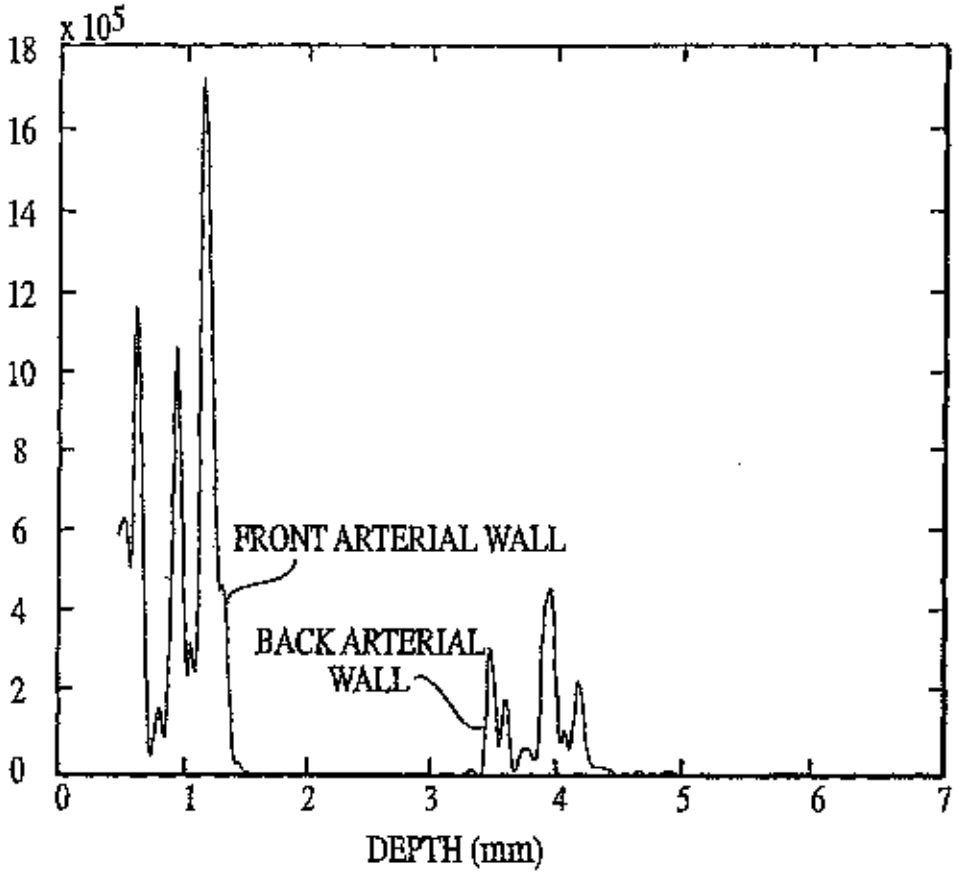


FIG. 24

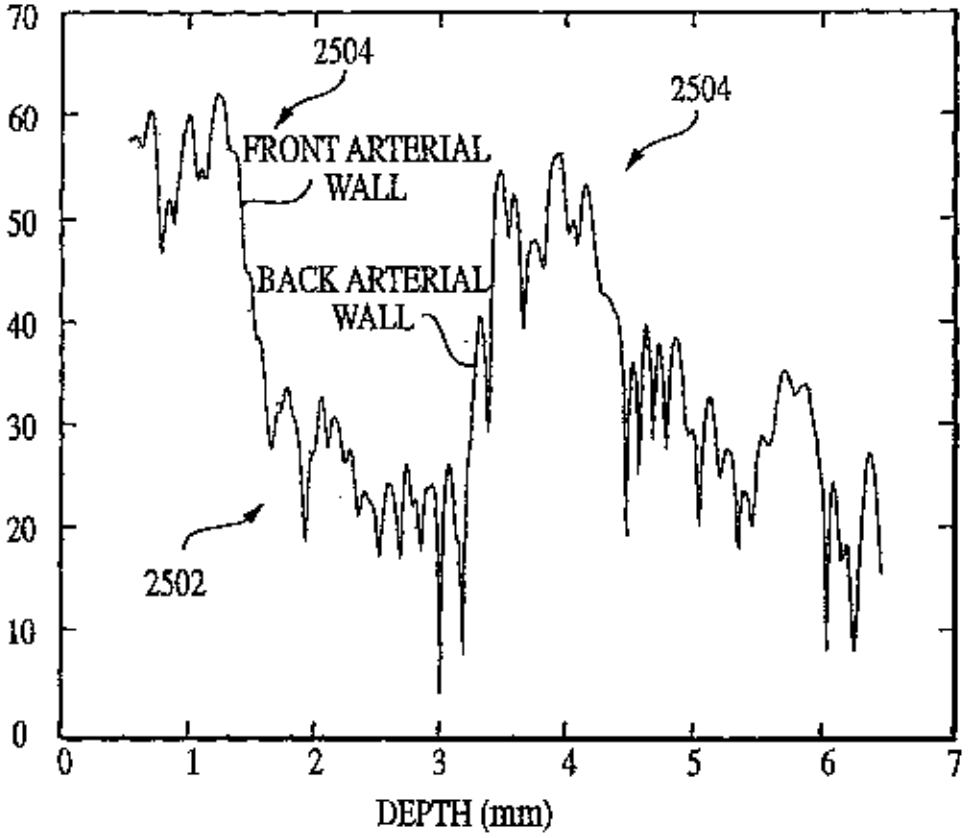

70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
2504
2504
FRONT ARTERIAL WALL
BACK ARTERIAL WALL
2502
DEPTH (mm)

FIG. 25

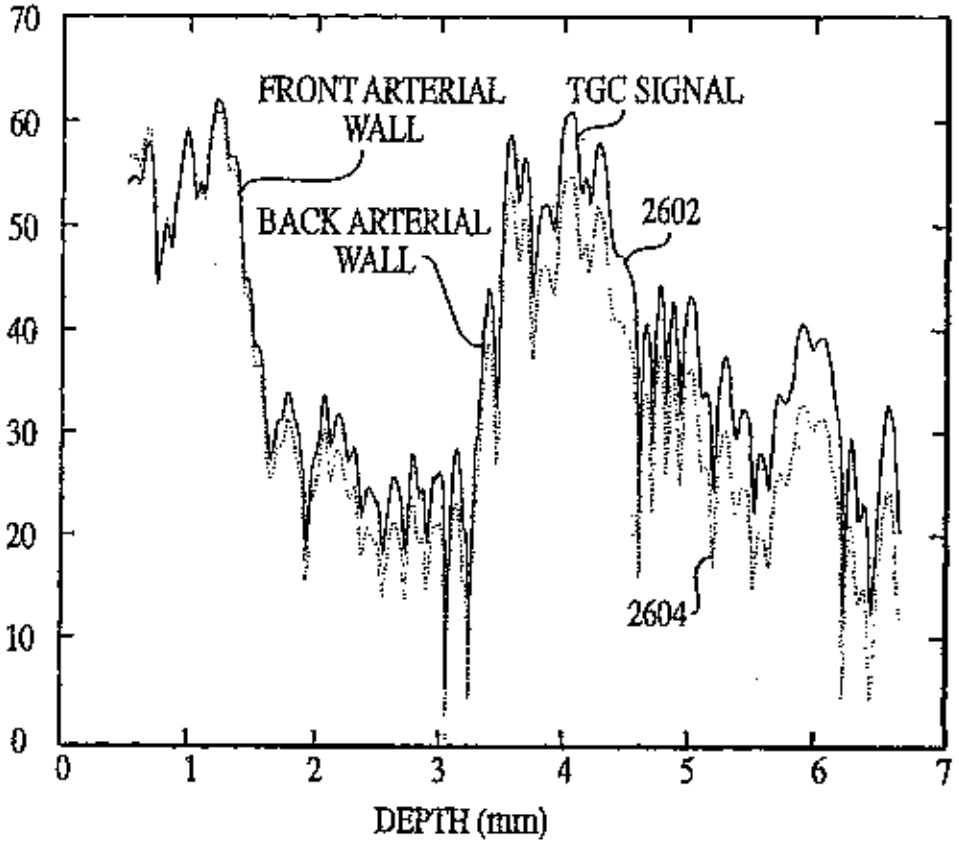

70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
FRONT ARTERIAL WALL
BACK ARTERIAL WALL
TGC SIGNAL
2602
2604
DEPTH (mm)

FIG. 26

24 JAN 2005

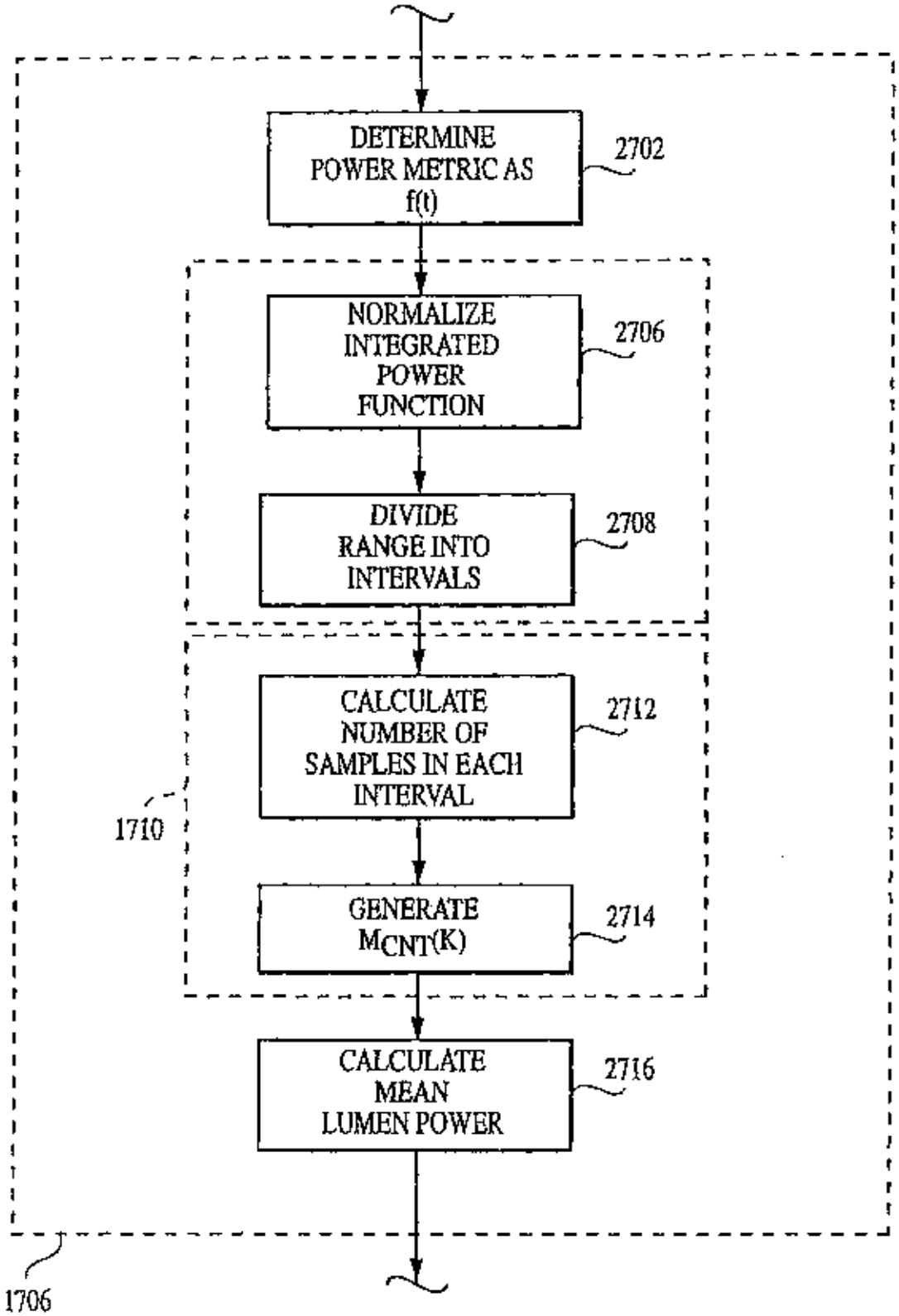


FIG. 27a

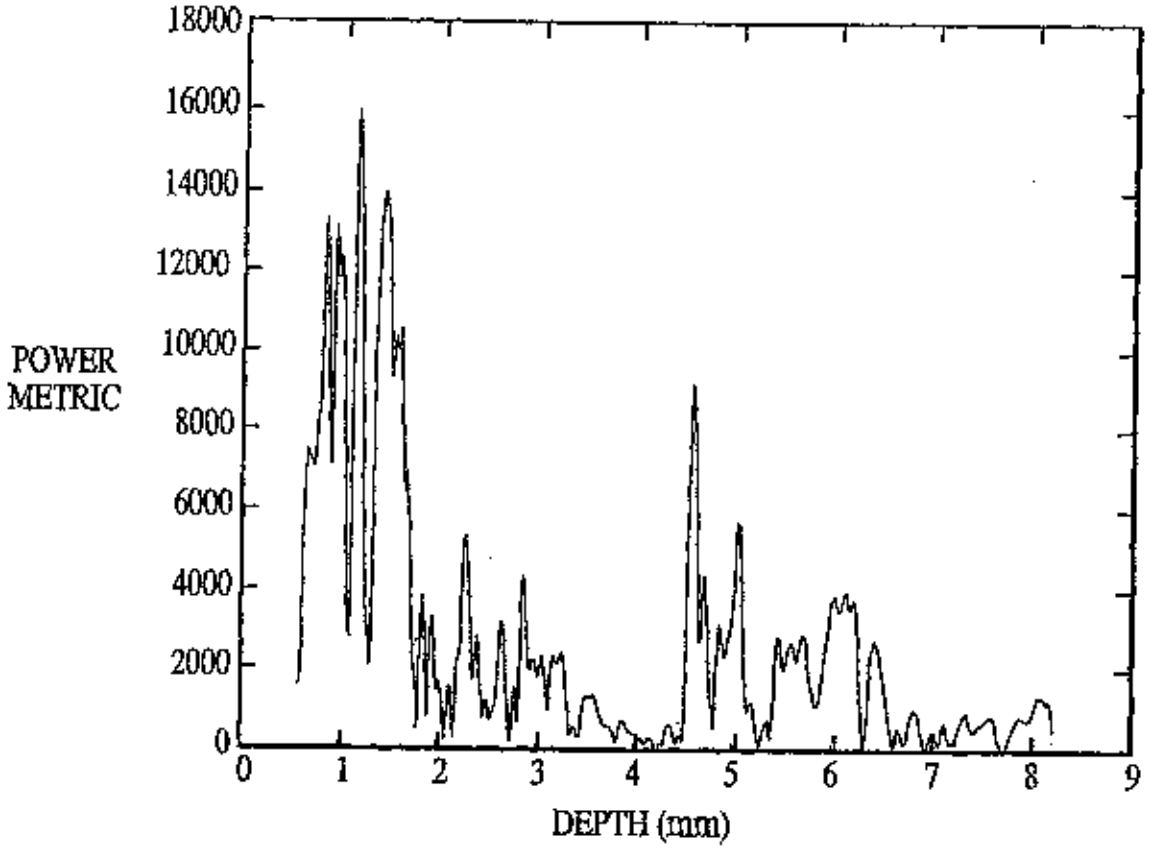

POWER METRIC
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0
1
2
3
4
5
6
7
8
9
DEPTH (mm)

FIG. 27b

24 JAN 2005

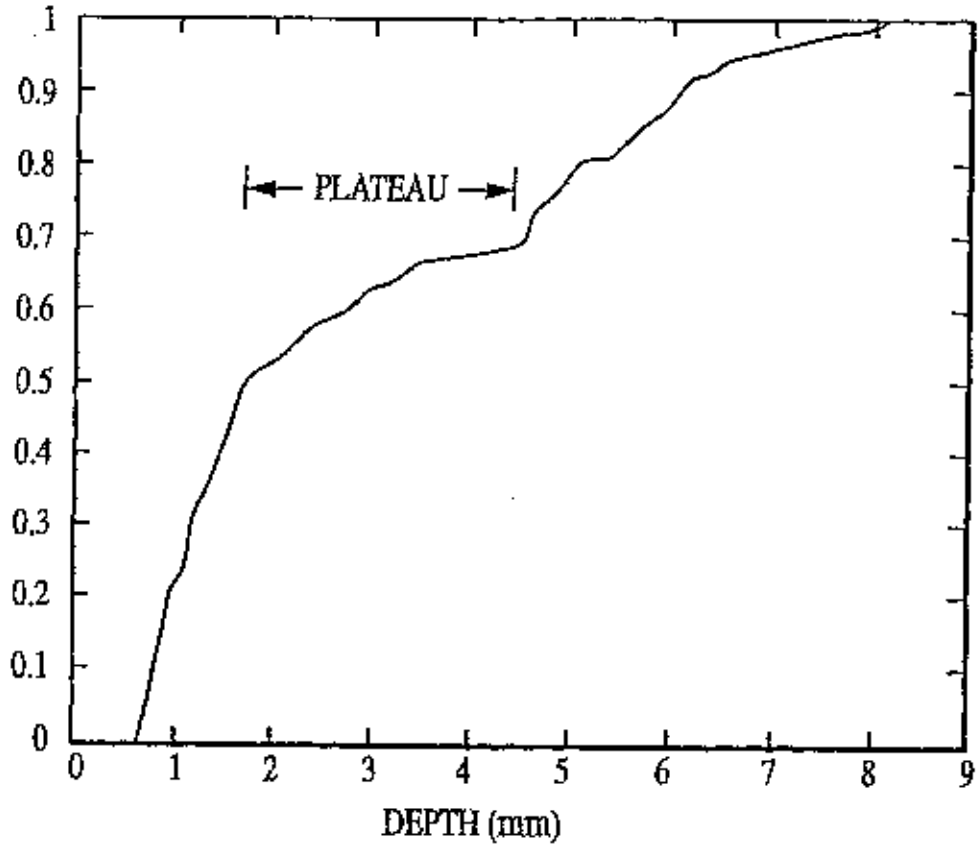


FIG. 27c

24 JAN 2005

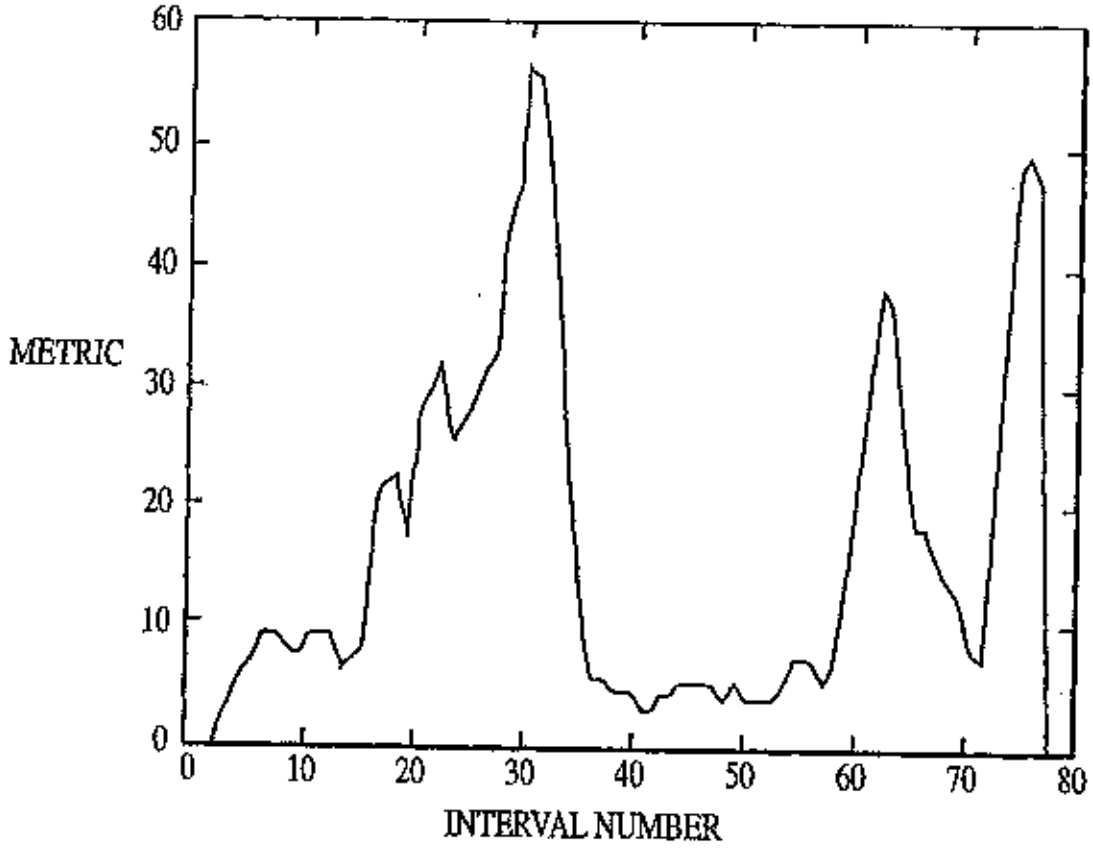


FIG. 27d

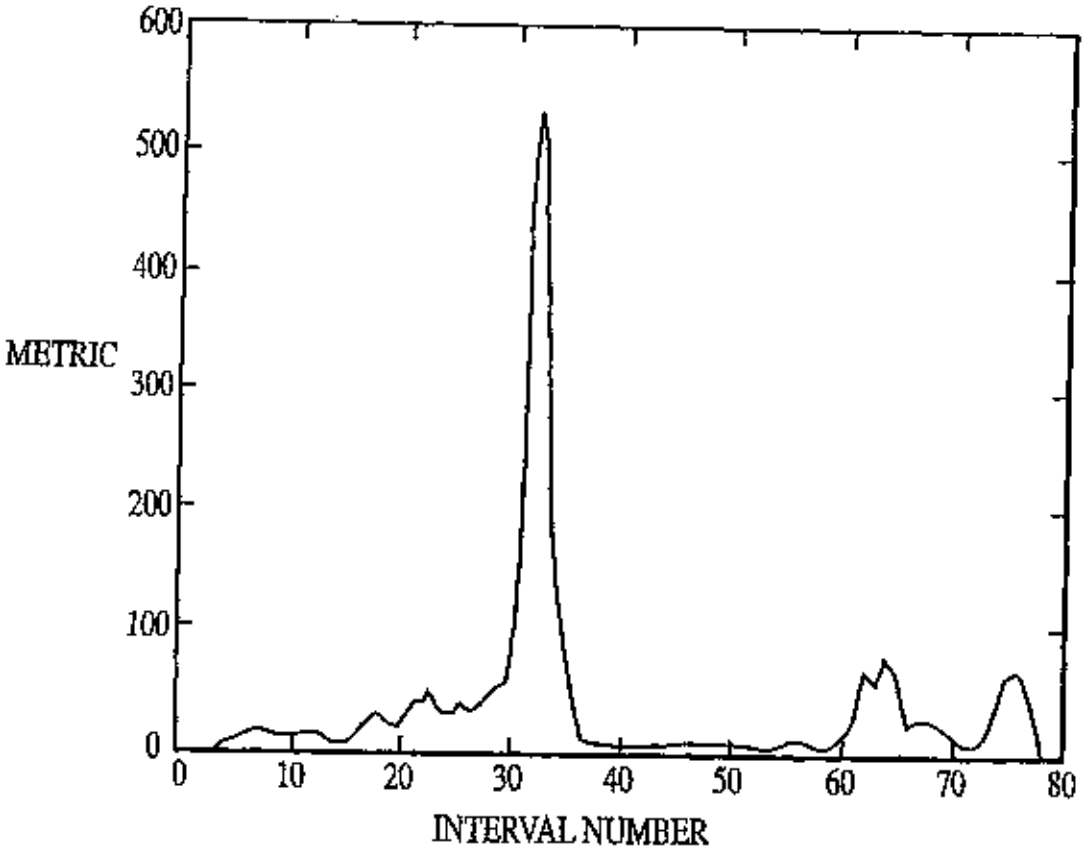

600
500
400
300
200
100
0
METRIC
0
10
20
30
40
50
60
70
80
INTERVAL NUMBER

FIG. 27e

24 JAN 2005

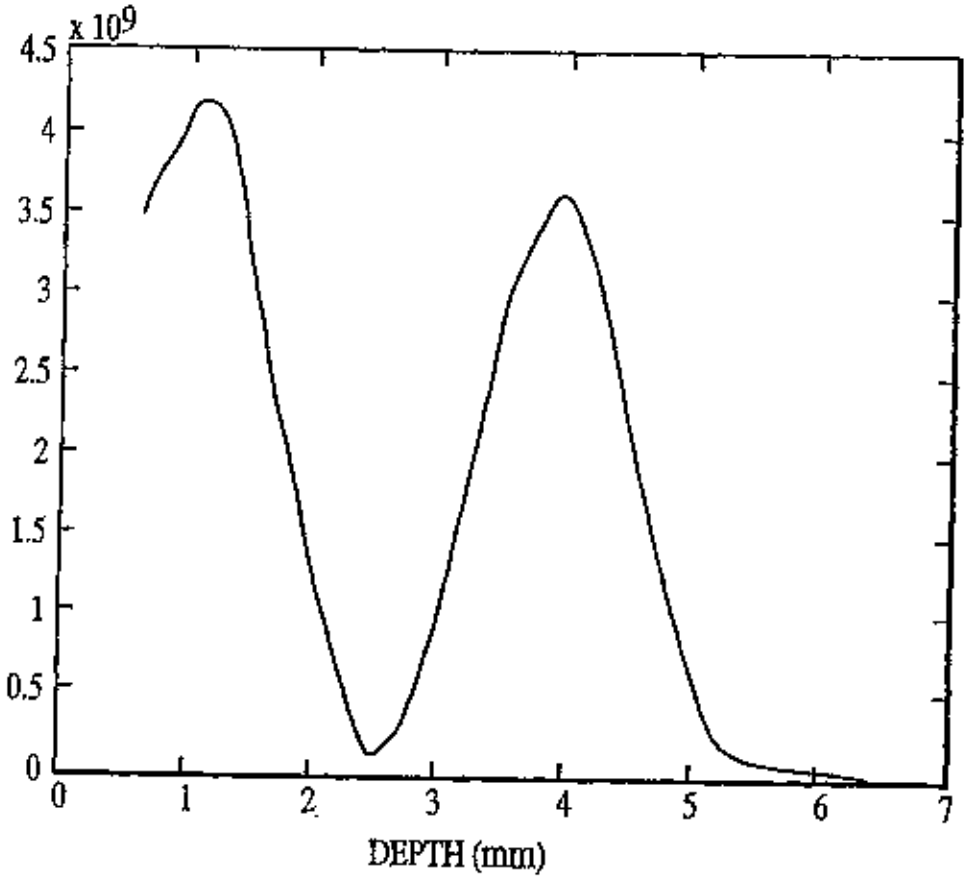


FIG. 28a

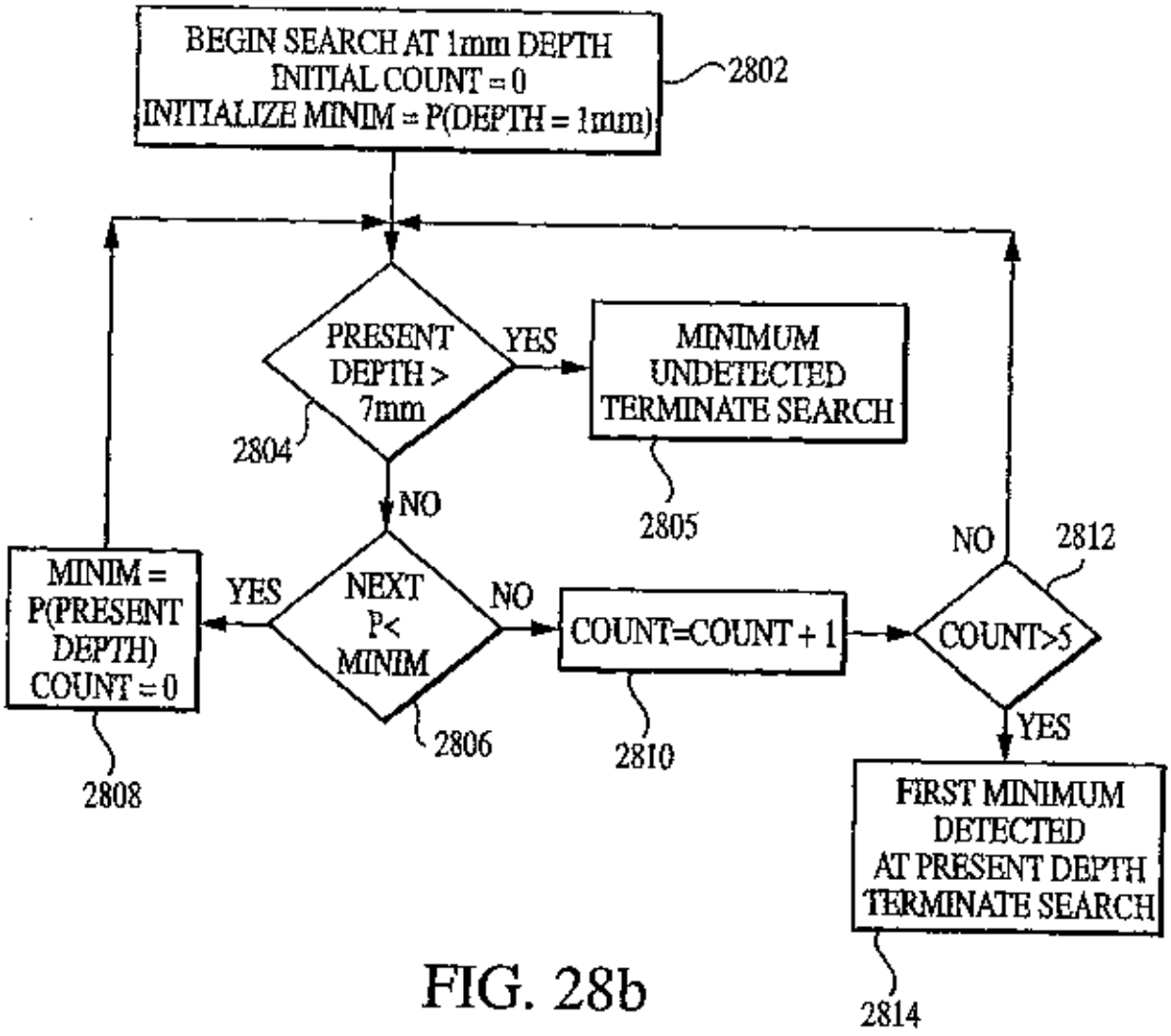

BEGIN SEARCH AT 1mm DEPTH
INITIAL COUNT = 0
INITIALIZE MINIM = P(DEPTH = 1mm)
2802
PRESENT DEPTH > 7mm
YES
MINIMUM UNDETECTED TERMINATE SEARCH
2804
2805
NO
MINIM = P(PRESENT DEPTH) COUNT = 0
YES
NEXT P< MINIM
NO
COUNT=COUNT + 1
COUNT>5
NO
2812
YES
2808
2806
2810
FIRST MINIMUM DETECTED AT PRESENT DEPTH TERMINATE SEARCH
2814

FIG. 28b

24 JAN 2005

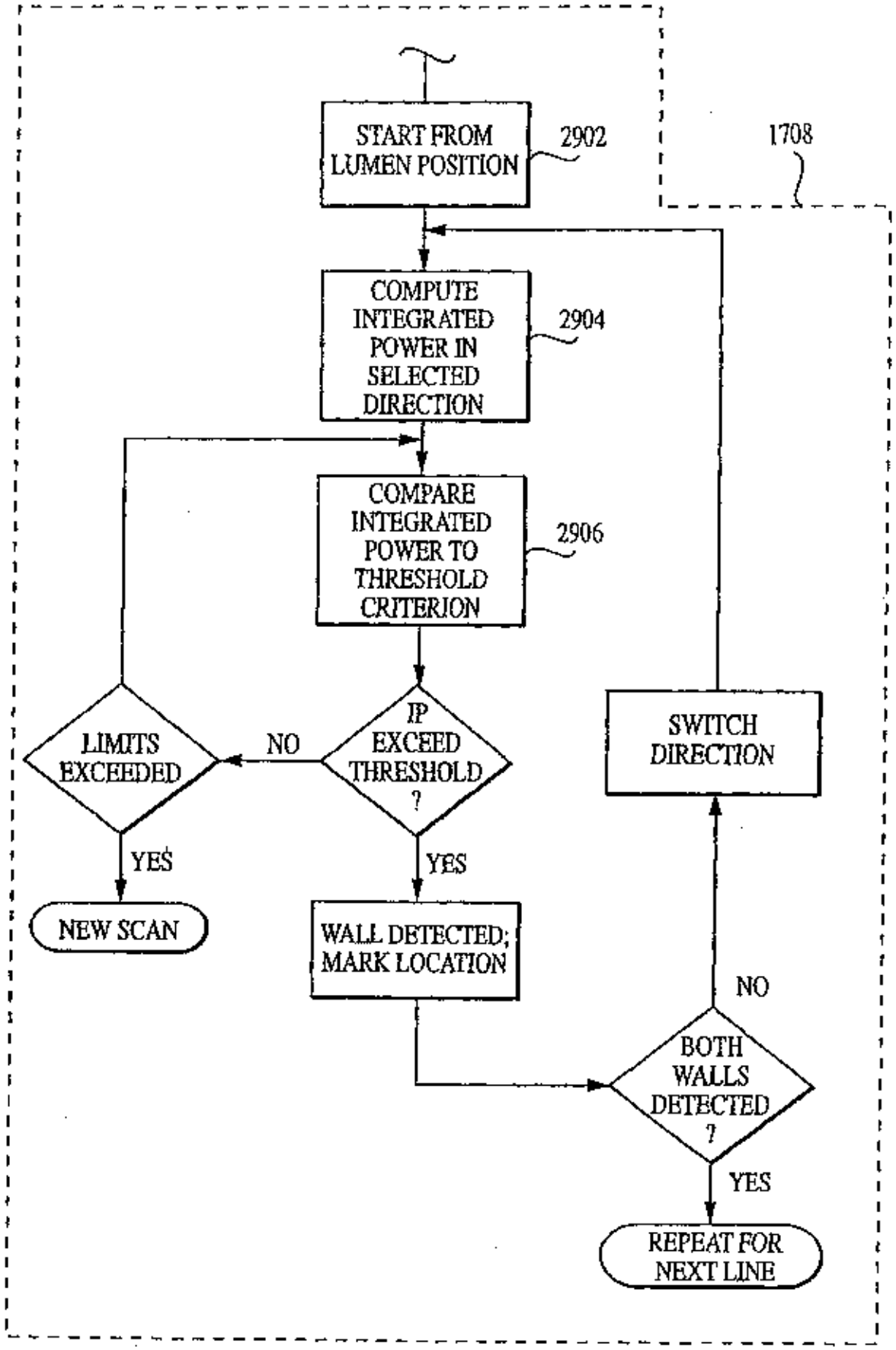


FIG. 29a

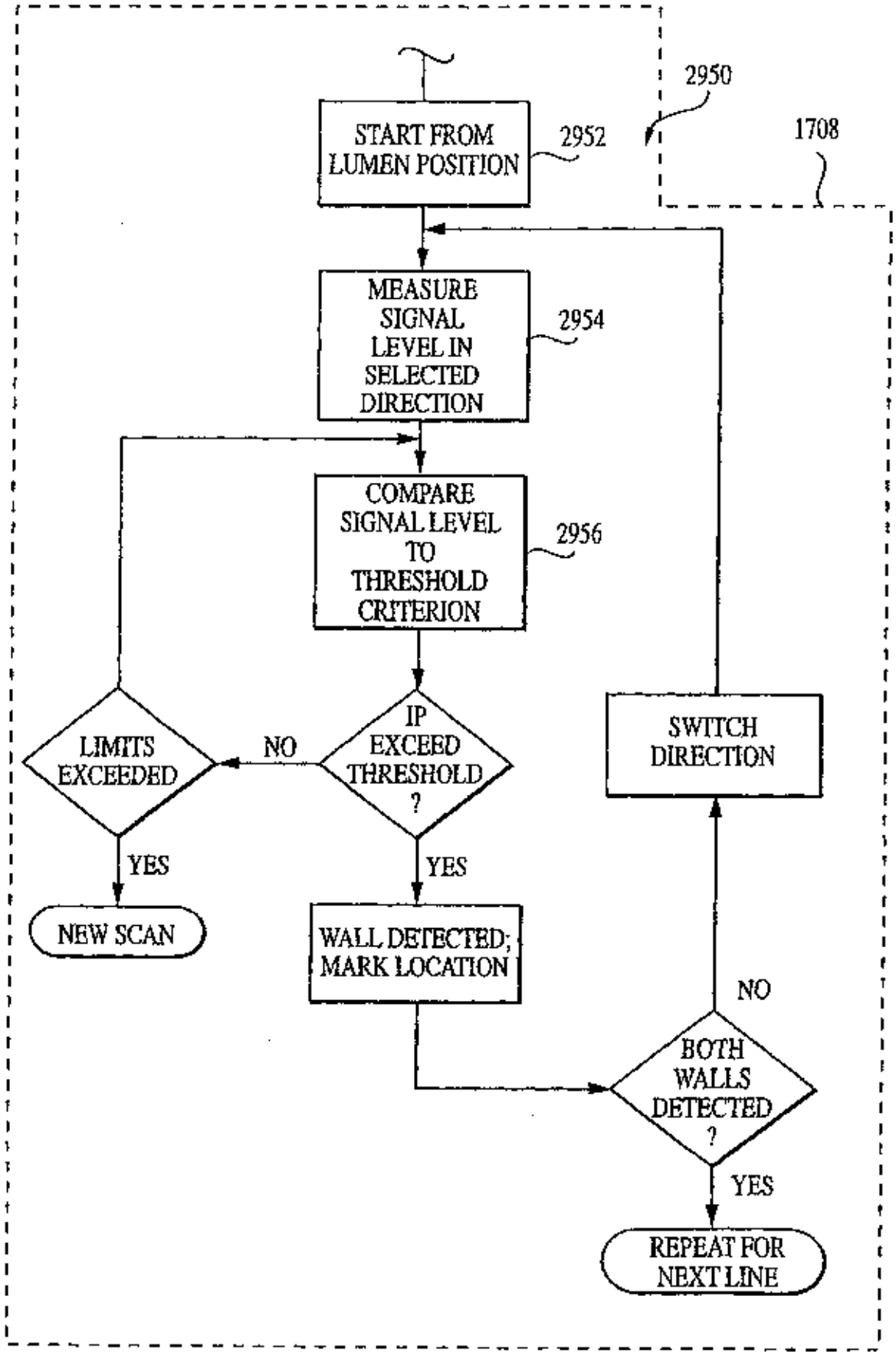

2950
1708
START FROM LUMEN POSITION
2952
MEASURE SIGNAL LEVEL IN SELECTED DIRECTION
2954
COMPARE SIGNAL LEVEL TO THRESHOLD CRITERION
2956
IP EXCEED THRESHOLD ?
NO
LIMITS EXCEEDED
YES
NEW SCAN
YES
WALL DETECTED; MARK LOCATION
SWITCH DIRECTION
NO
BOTH WALLS DETECTED ?
YES
REPEAT FOR NEXT LINE

FIG. 29b

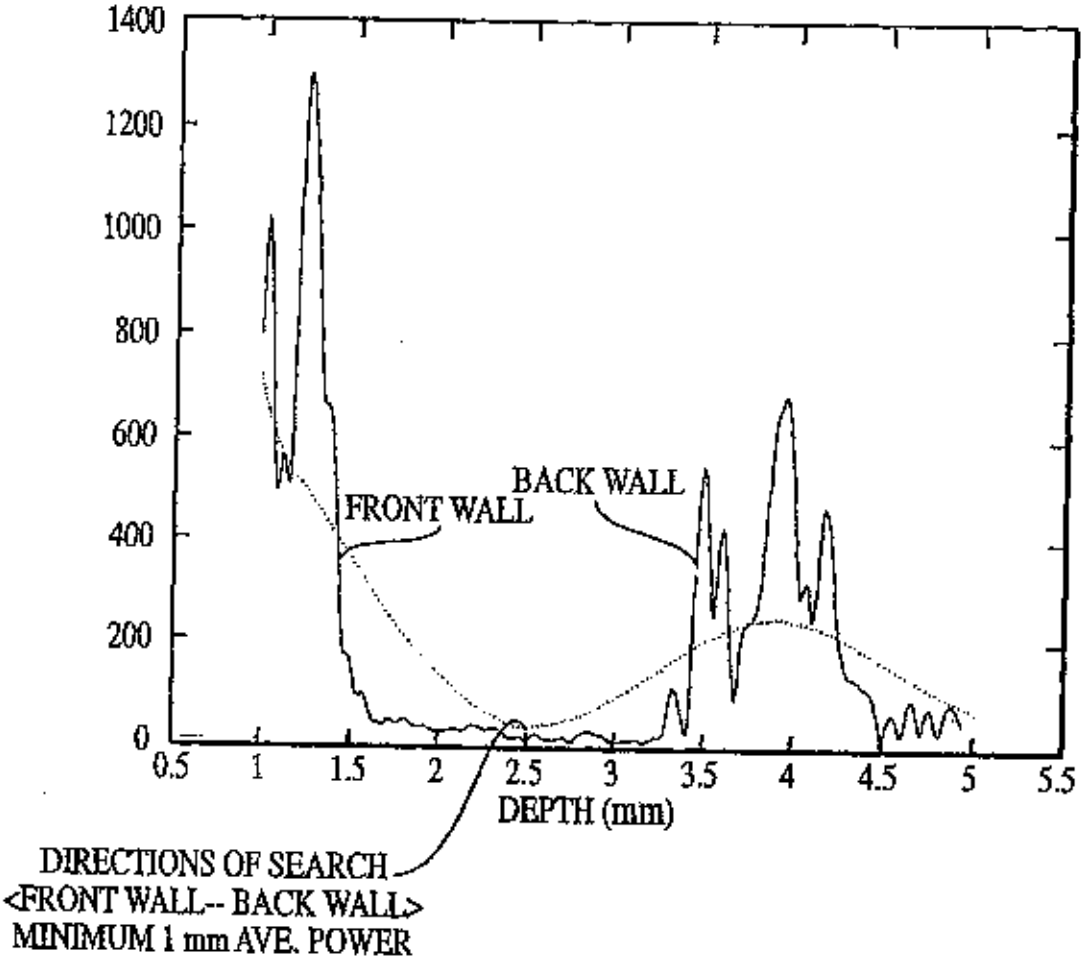

1400
1200
1000
800
600
400
200
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
DEPTH (mm)
FRONT WALL
BACK WALL
DIRECTIONS OF SEARCH
<FRONT WALL-- BACK WALL>
MINIMUM 1 mm AVE. POWER

FIG. 30

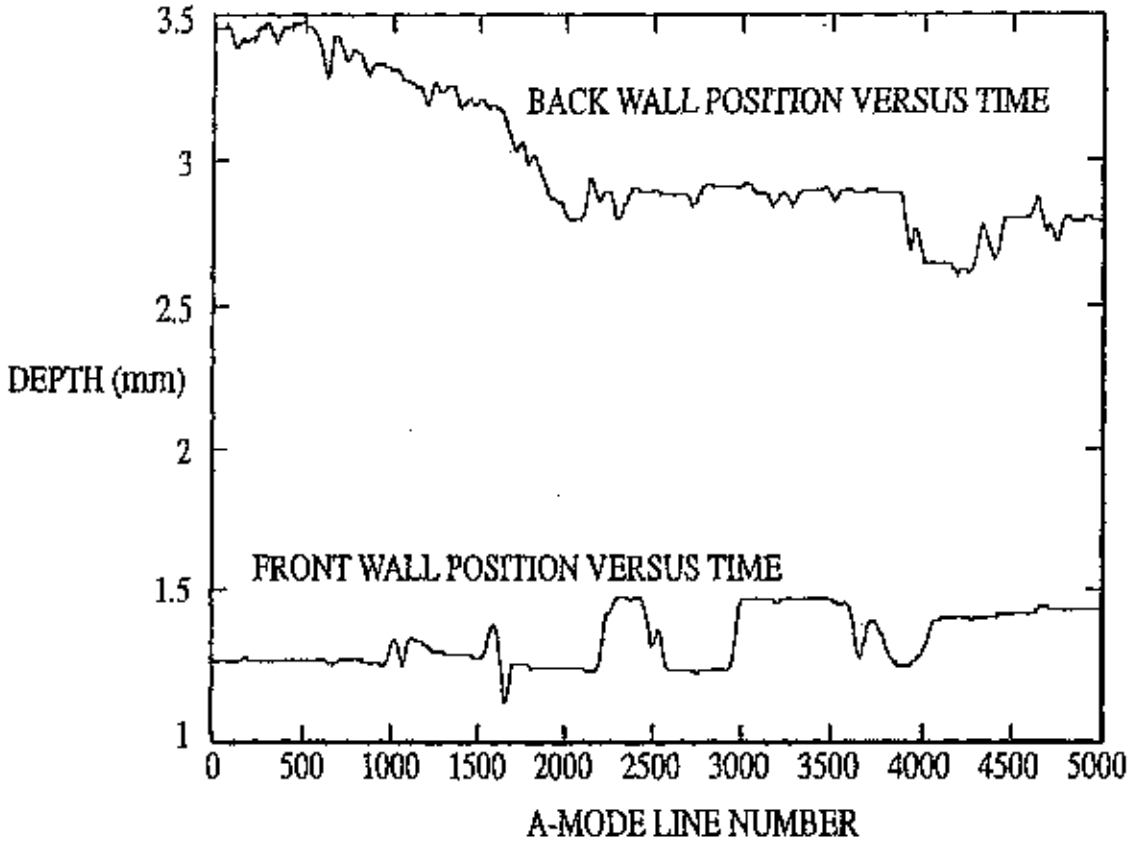

3.5
3
2.5
2
1.5
1
DEPTH (mm)
BACK WALL POSITION VERSUS TIME
FRONT WALL POSITION VERSUS TIME
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
A-MODE LINE NUMBER

FIG. 31

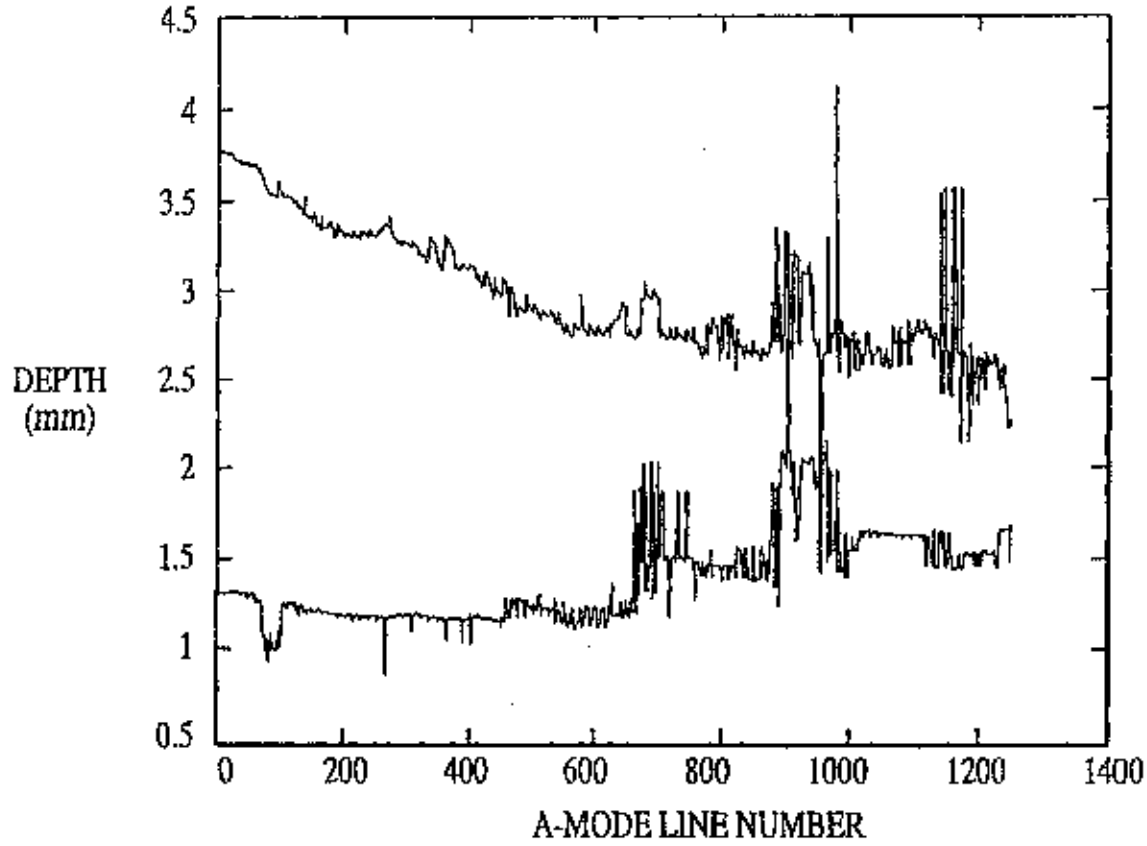

DEPTH
(mm)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
200
400
600
800
1000
1200
1400
A-MODE LINE NUMBER

FIG. 32

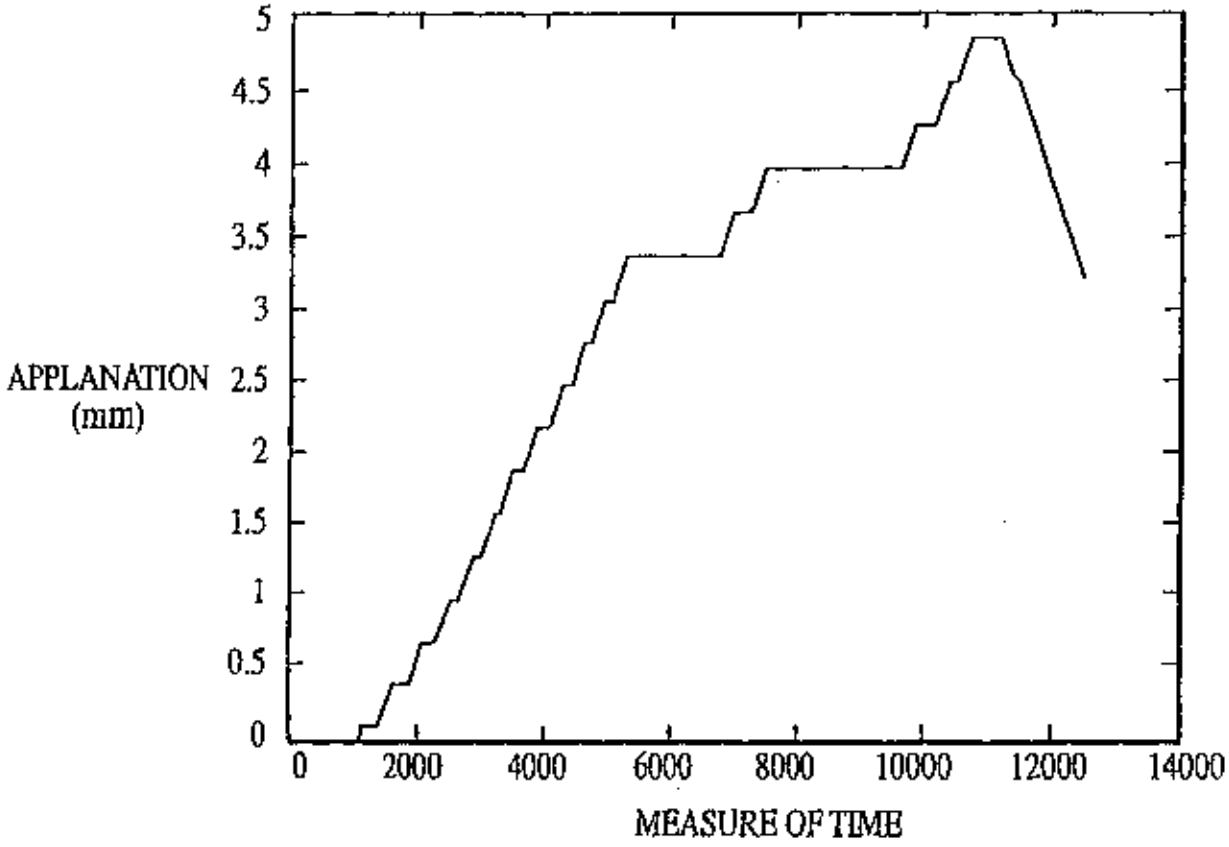

APPLANATION
(mm)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
2000
4000
6000
8000
10000
12000
14000
MEASURE OF TIME

FIG. 32a

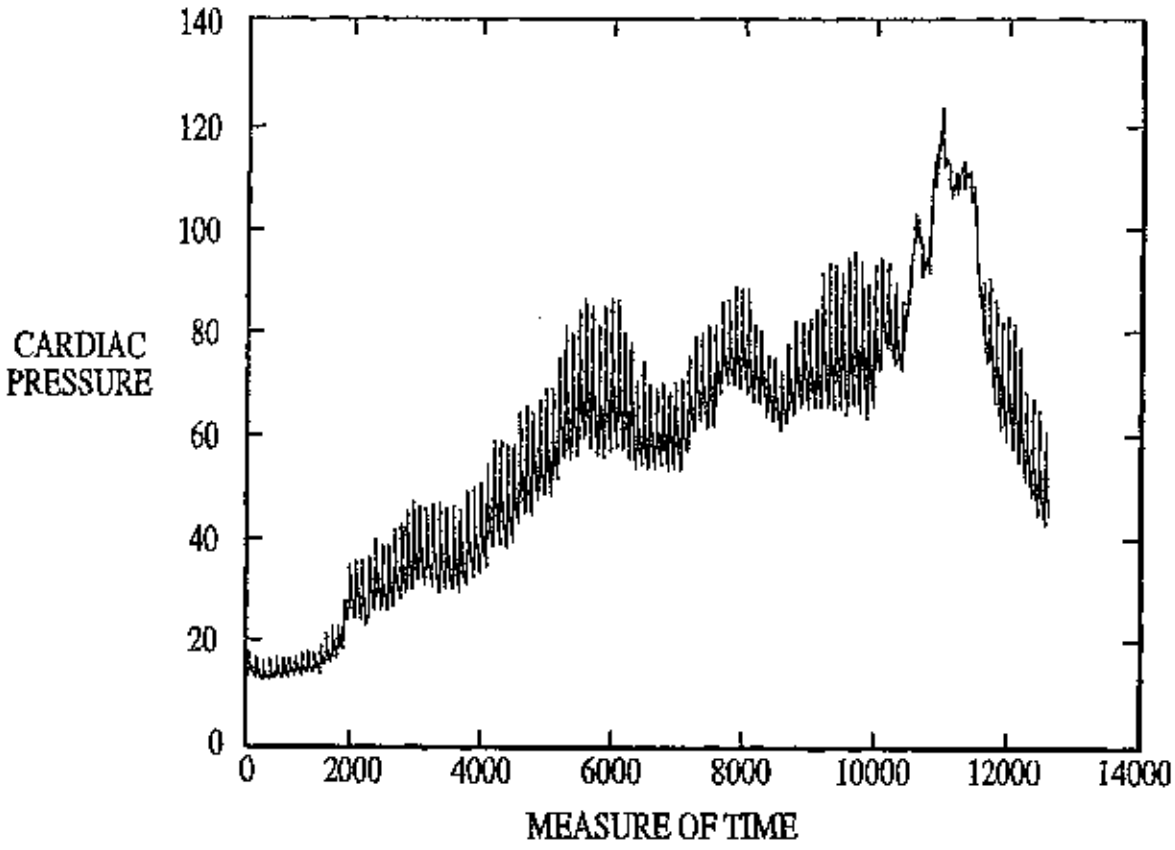

CARDIAC PRESSURE
140
120
100
80
60
40
20
0
0
2000
4000
6000
8000
10000
12000
14000
MEASURE OF TIME

FIG. 32b

24 JAN 2005

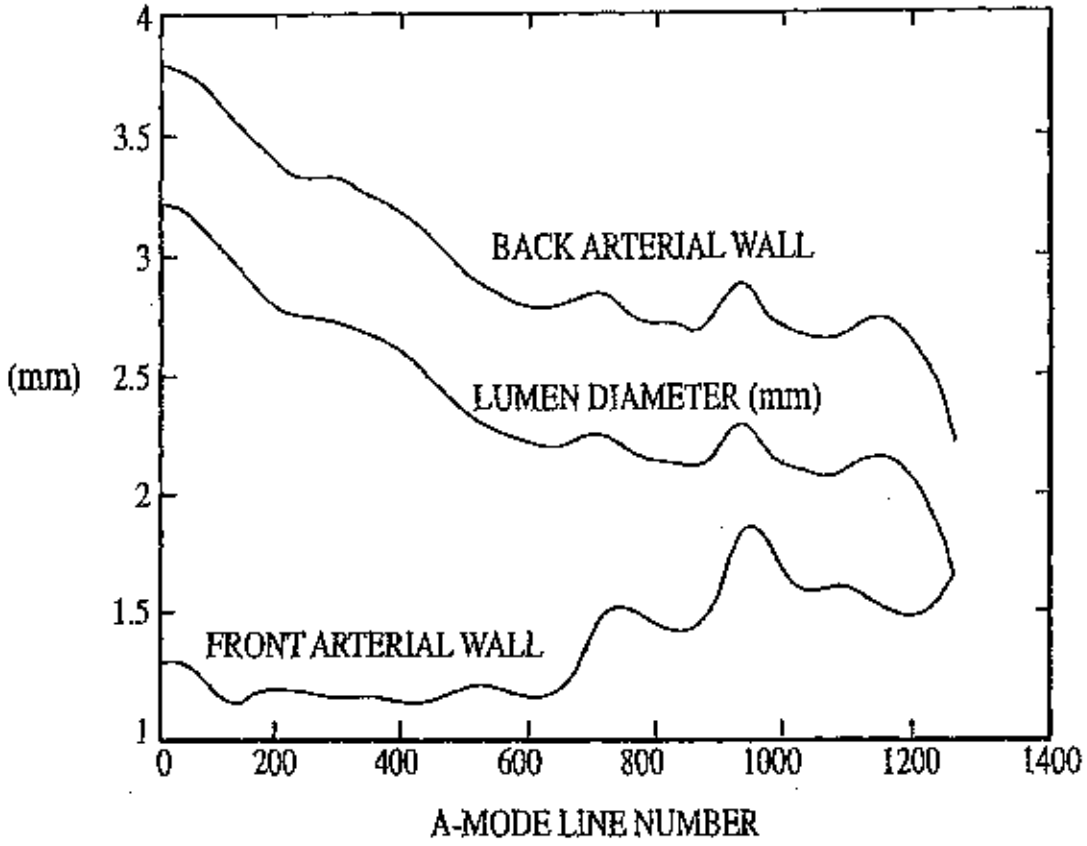


FIG. 33

24 JAN 2005

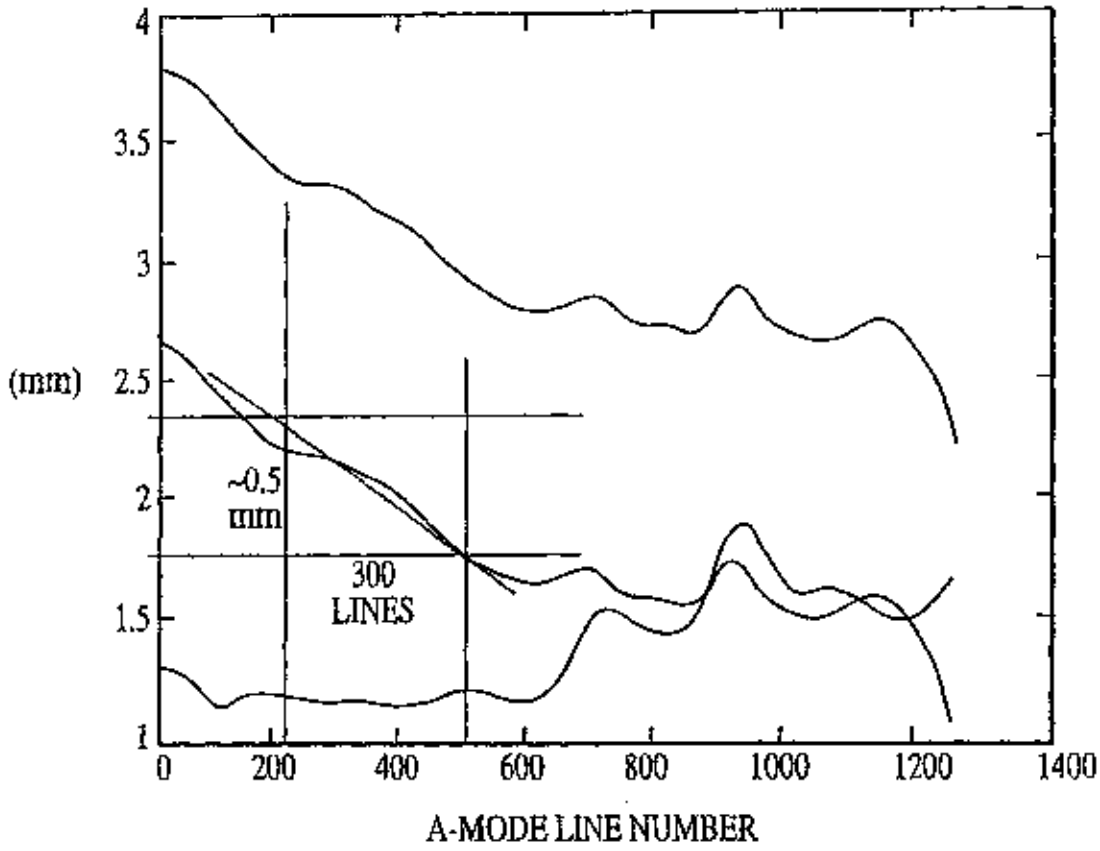


FIG. 34

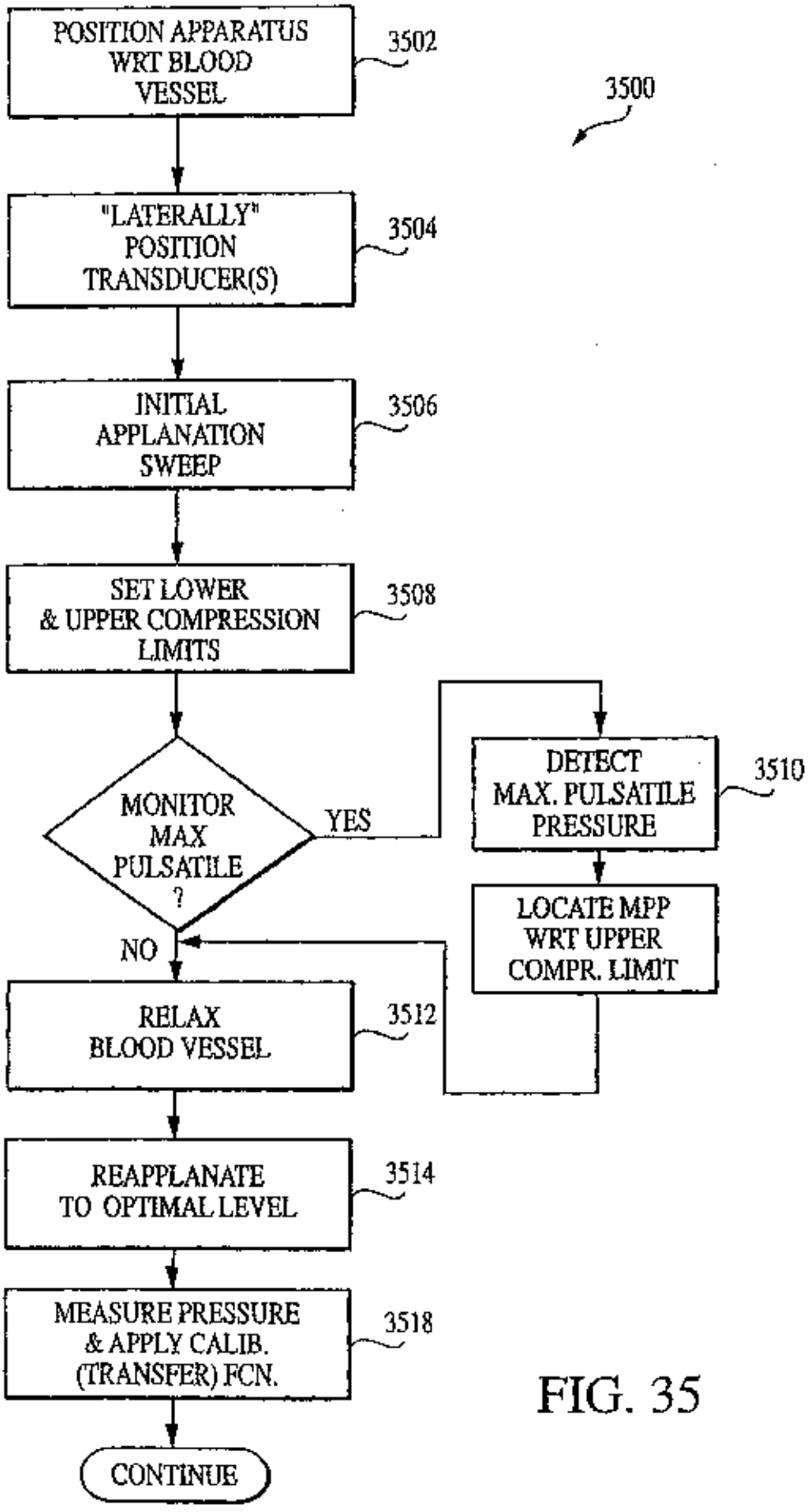

POSITION APPARATUS WRT BLOOD VESSEL
3502
3500
"LATERALLY" POSITION TRANSDUCER(S)
3504
INITIAL APPLANATION SWEEP
3506
SET LOWER & UPPER COMPRESSION LIMITS
3508
MONITOR MAX PULSATILE ?
YES
NO
DETECT MAX. PULSATILE PRESSURE
3510
LOCATE MPP WRT UPPER COMPR. LIMIT
RELAX BLOOD VESSEL
3512
REAPPLANATE TO OPTIMAL LEVEL
3514
MEASURE PRESSURE & APPLY CALIB. (TRANSFER) FCN.
3518
CONTINUE

FIG. 35

24 JAN 2005

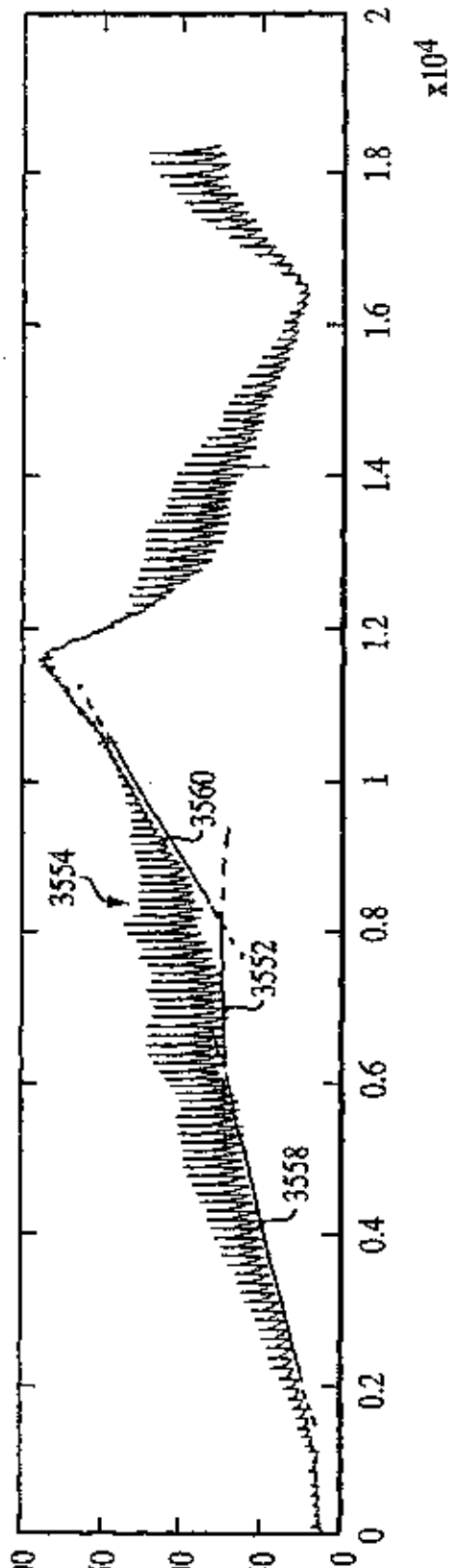


FIG. 35a

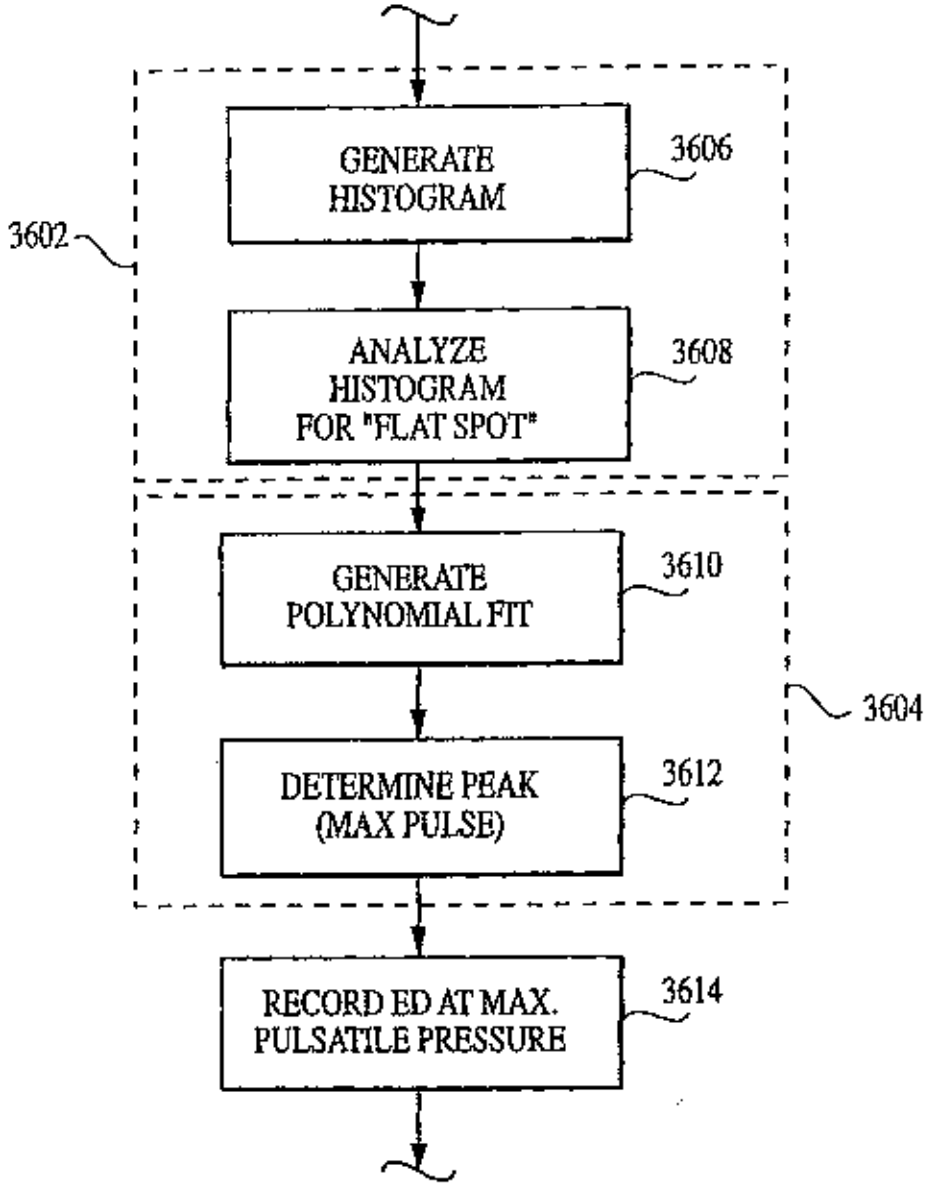

GENERATE HISTOGRAM
3606
3602
ANALYZE HISTOGRAM FOR "FLAT SPOT"
3608
GENERATE POLYNOMIAL FIT
3610
3604
DETERMINE PEAK (MAX PULSE)
3612
RECORD ED AT MAX. PULSATILE PRESSURE
3614

FIG. 36

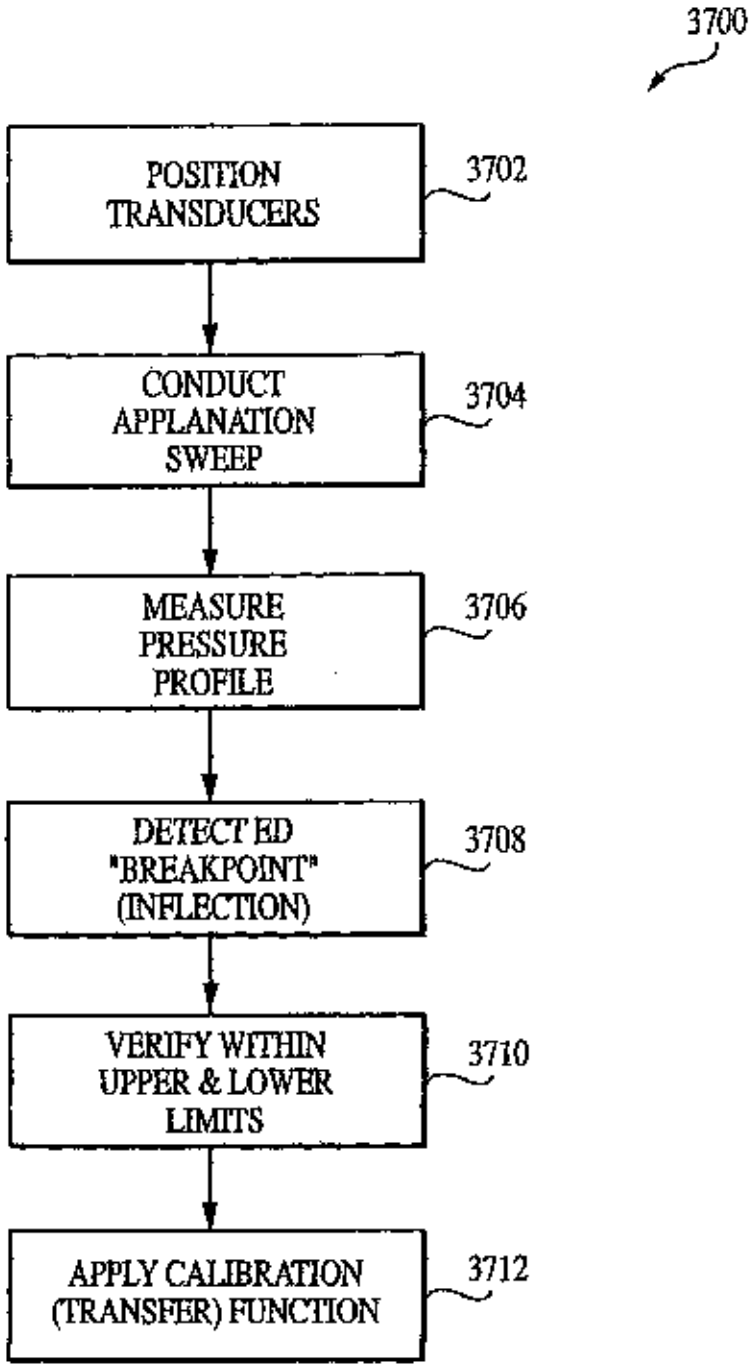
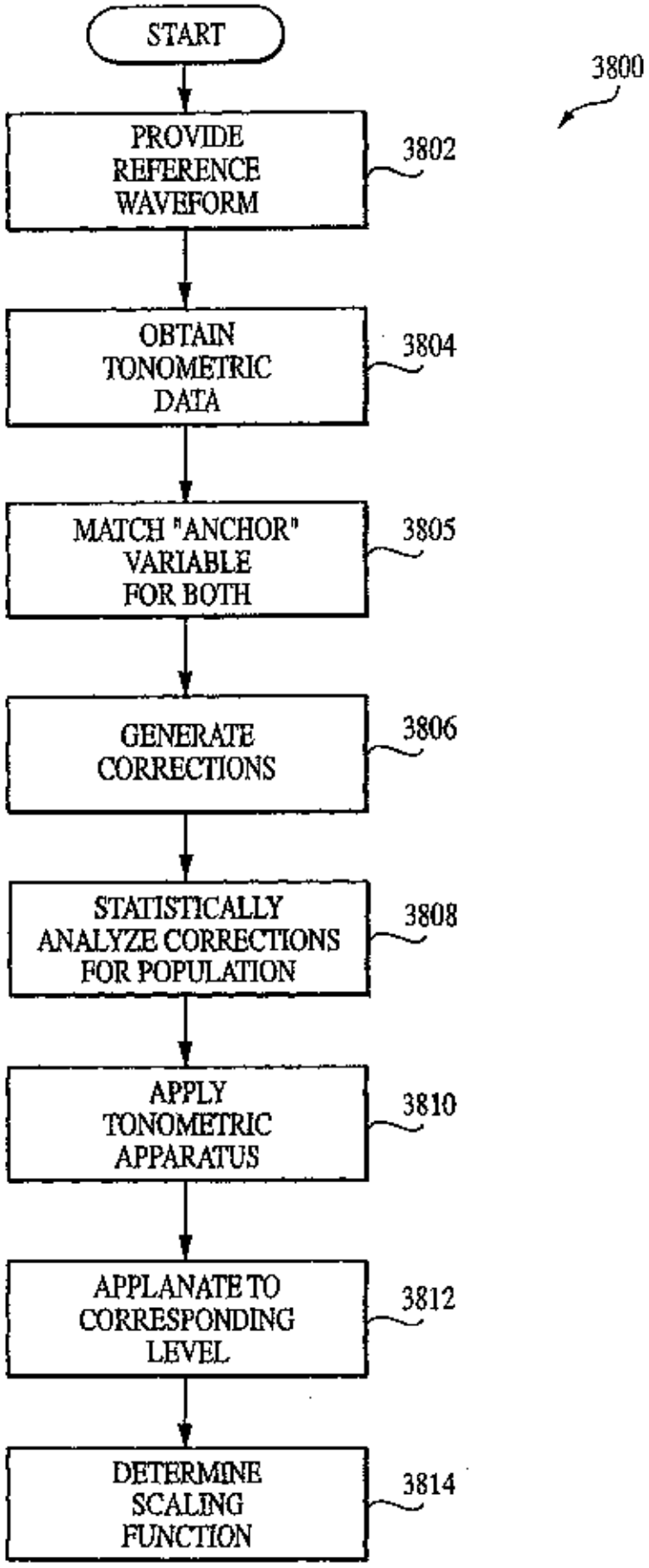

3700
POSITION TRANSDUCERS
3702
CONDUCT APPLANATION SWEEP
3704
MEASURE PRESSURE PROFILE
3706
DETECT ED "BREAKPOINT" (INFLECTION)
3708
VERIFY WITHIN UPPER & LOWER LIMITS
3710
APPLY CALIBRATION (TRANSFER) FUNCTION
3712

FIG. 37

FIG. 38


START
3800
PROVIDE REFERENCE WAVEFORM
3802
OBTAIN TONOMETRIC DATA
3804
MATCH "ANCHOR" VARIABLE FOR BOTH
3805
GENERATE CORRECTIONS
3806
STATISTICALLY ANALYZE CORRECTIONS FOR POPULATION
3808
APPLY TONOMETRIC APPARATUS
3810
APPLANATE TO CORRESPONDING LEVEL
3812
DETERMINE SCALING FUNCTION
3814

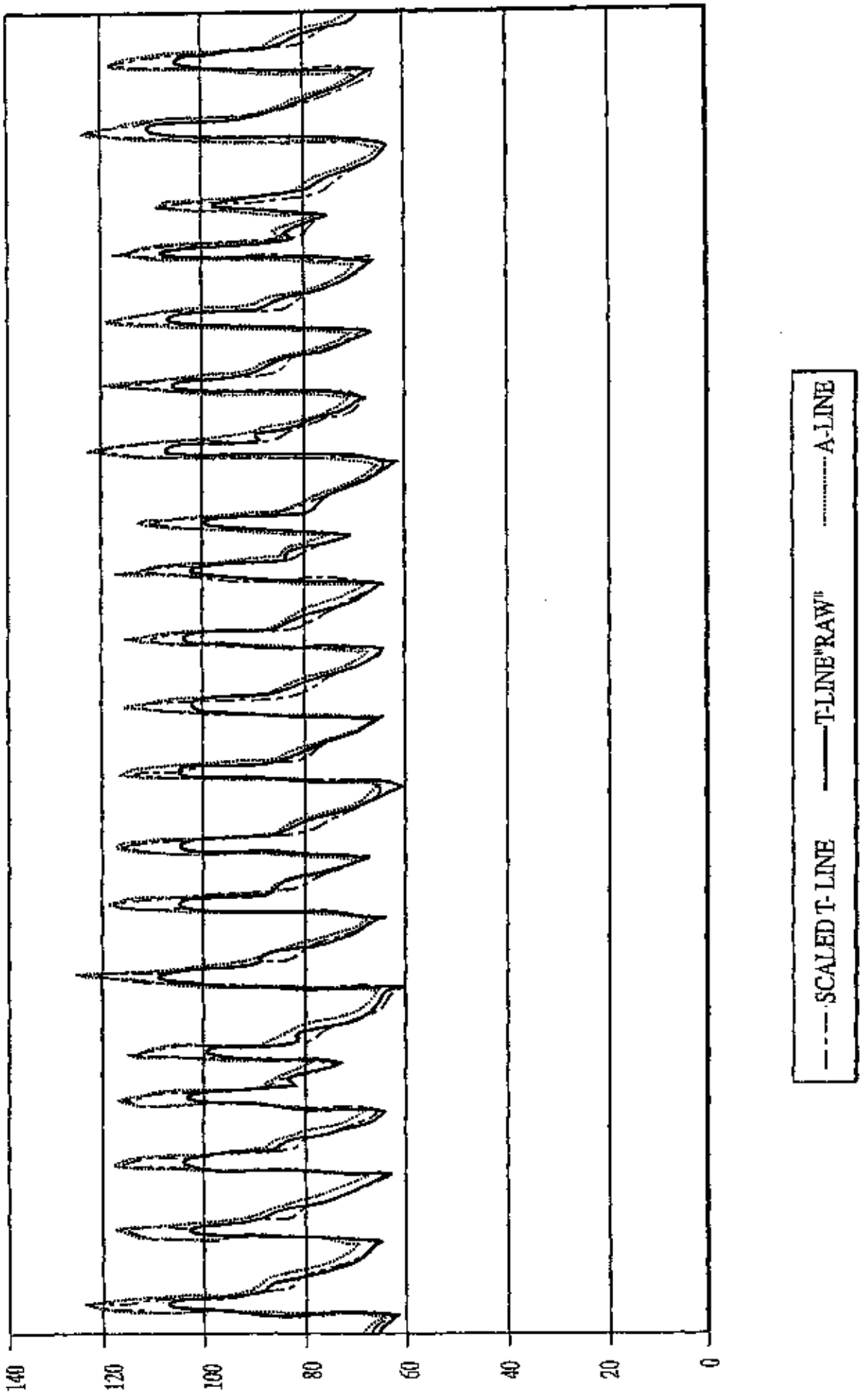


FIG. 39

24 JAN 2005

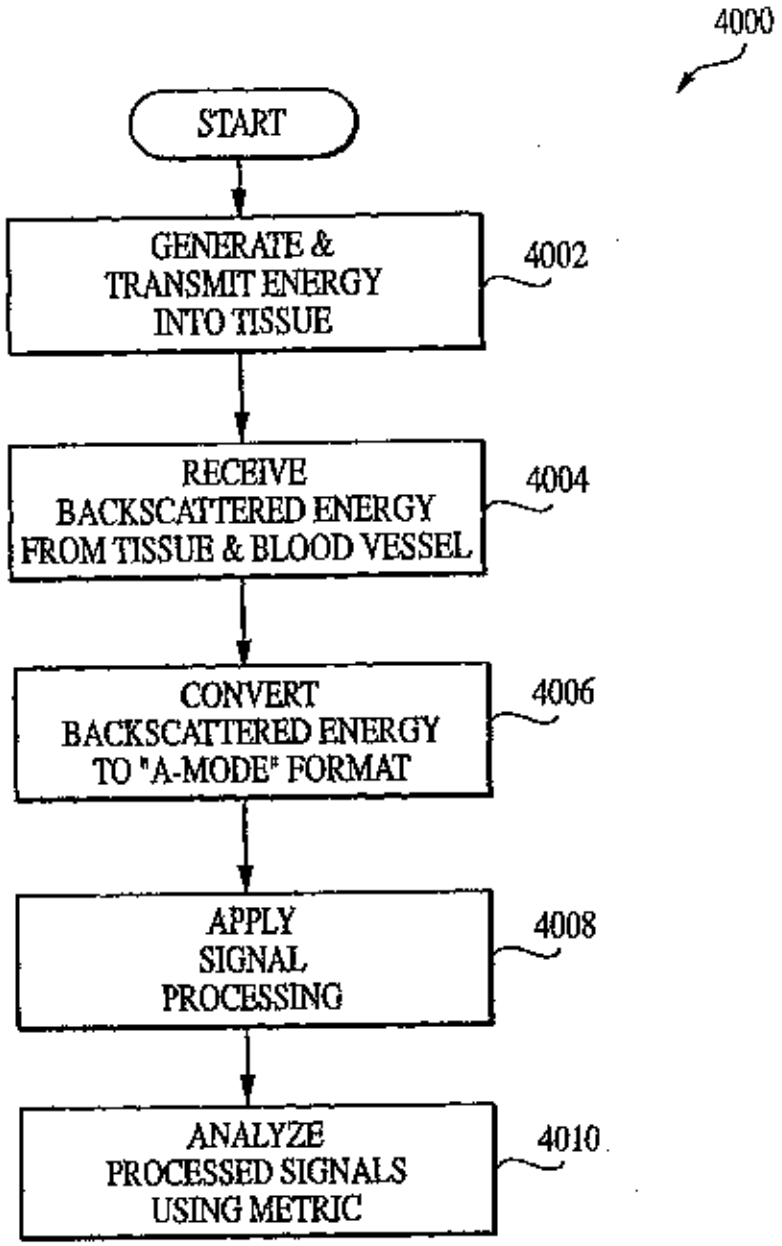


FIG. 40

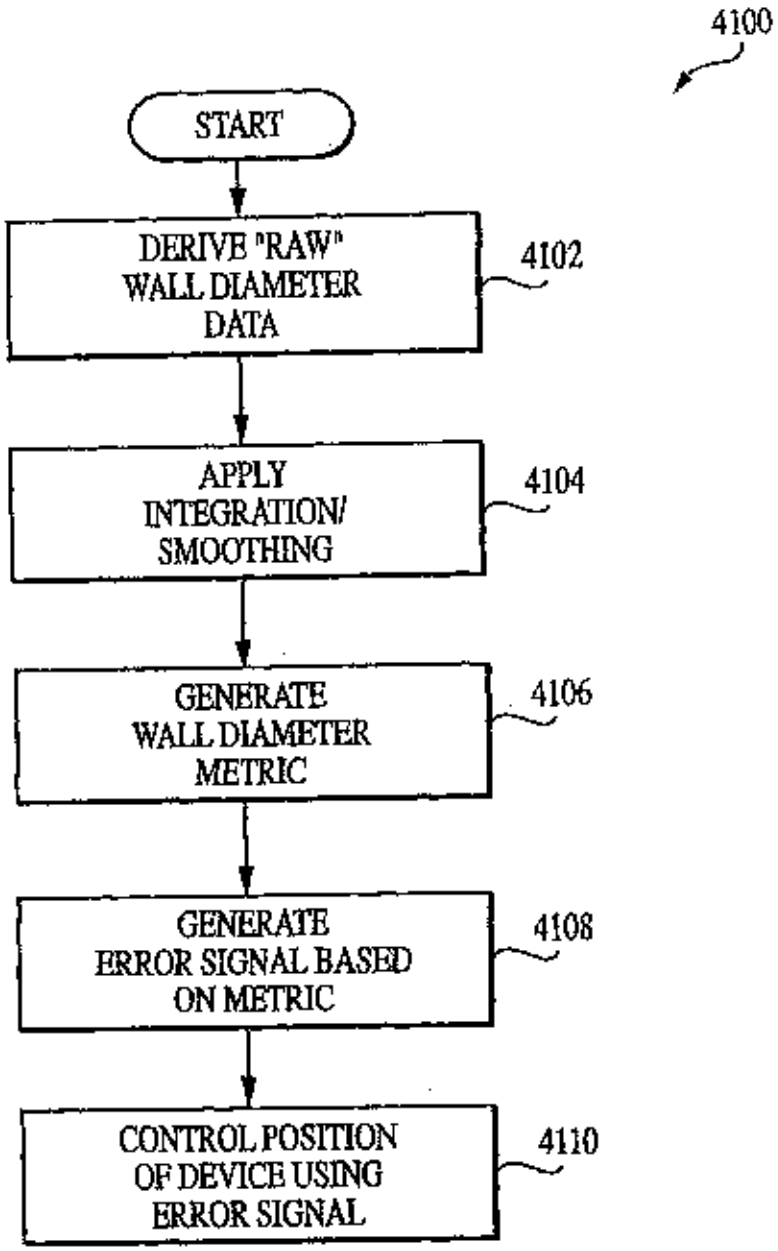

4100
START
DERIVE "RAW" WALL DIAMETER DATA
4102
APPLY INTEGRATION/ SMOOTHING
4104
GENERATE WALL DIAMETER METRIC
4106
GENERATE ERROR SIGNAL BASED ON METRIC
4108
CONTROL POSITION OF DEVICE USING ERROR SIGNAL
4110

FIG. 41