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(54) **SYSTEM AND METHOD FOR IMAGE PROCESSING OF MEDICAL TEST RESULTS USING GENERALIZED CURVE FIELD TRANSFORM**

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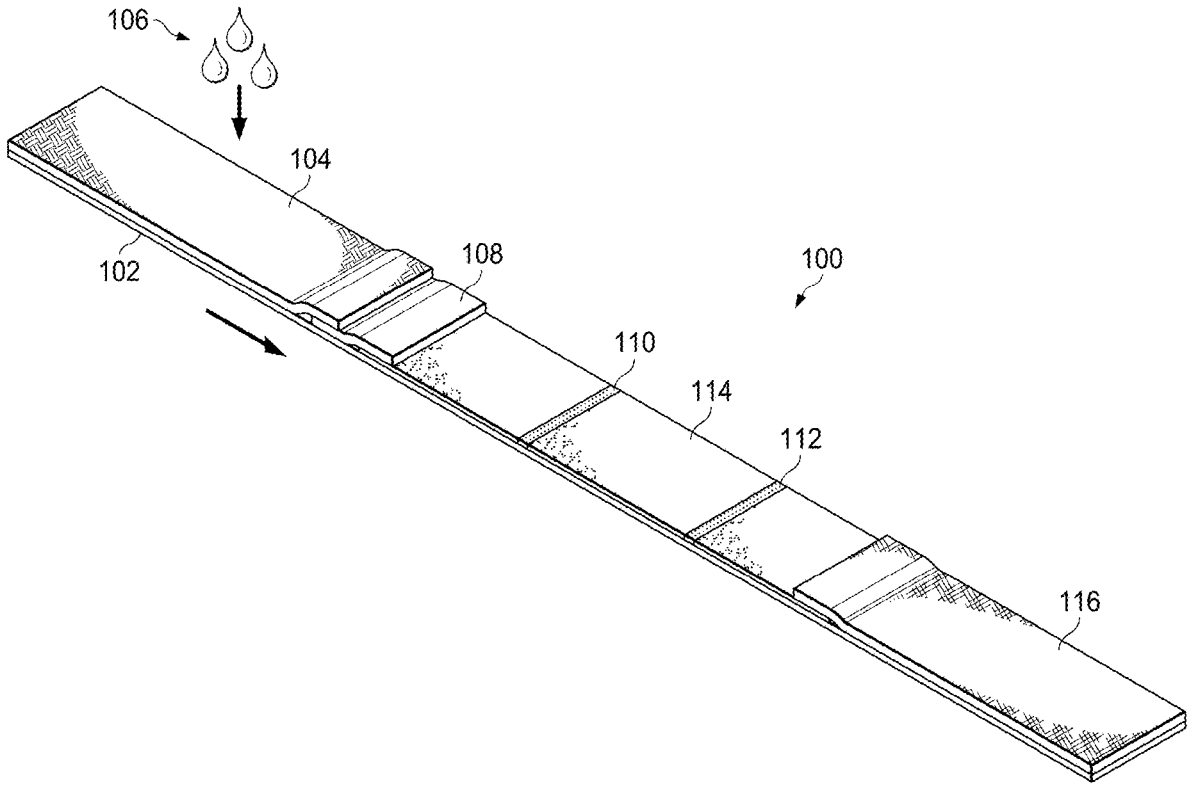
G01N 21/84	(2006.01)

(52) **U.S. Cl.**

CPC ***A61B 5/0013*** (2013.01); *G16H 10/60* (2018.01); ***G01N 21/8483*** (2013.01); ***G01N 33/53*** (2013.01)

(57) **ABSTRACT**

A method for image processing medical self-test results receives a digital image of a visual indication of a test result. A digital image is generated of the visual indication of the test result that includes noise and distortions therein. The digital image is processed using generalized curve field transforms to extract relevant features of the digital image in a presence of the noise and distortions to create a transformed image. A diagnosis is generated based upon the transformed image to the plurality of images of the test results.



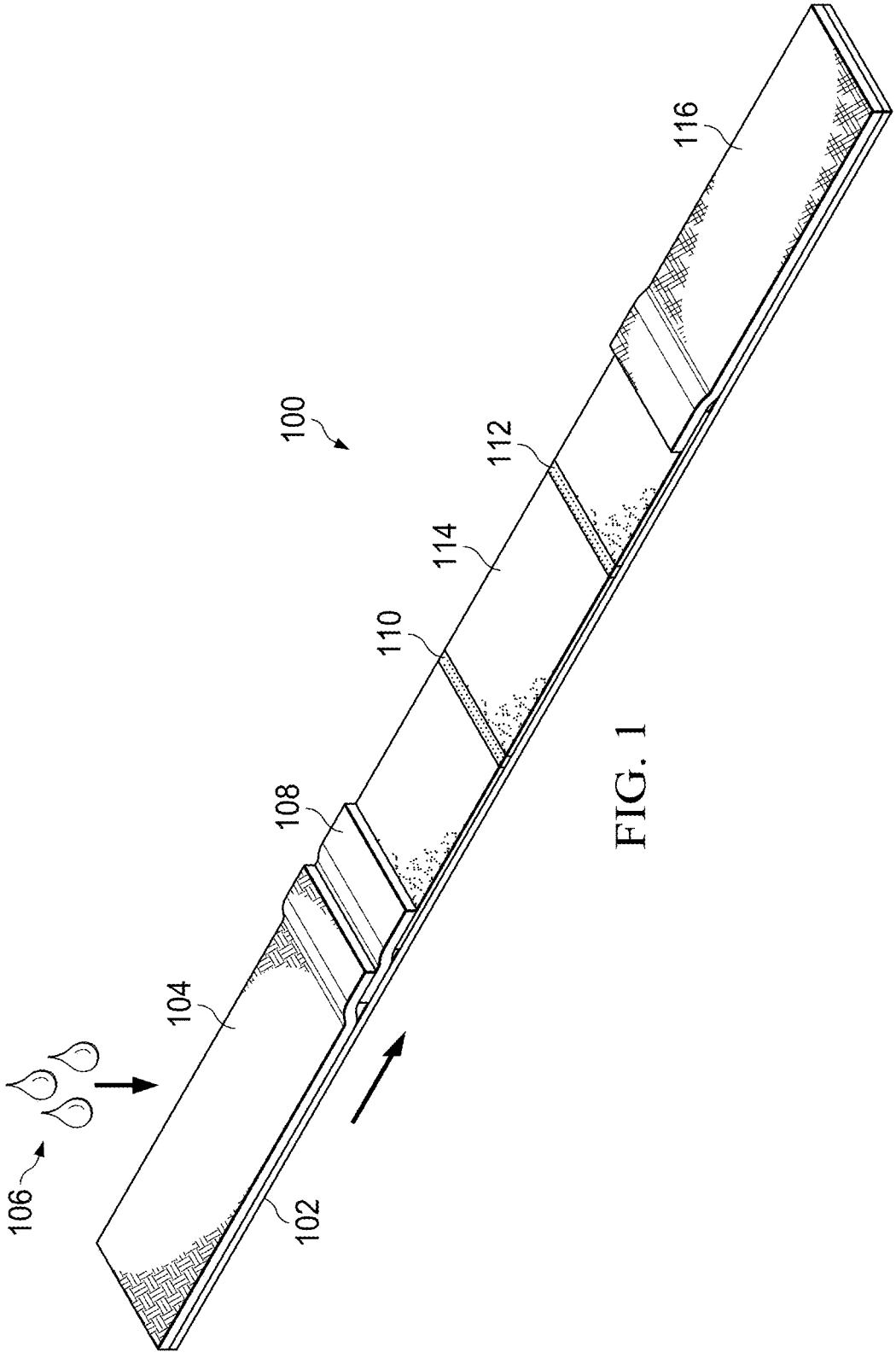


FIG. 1

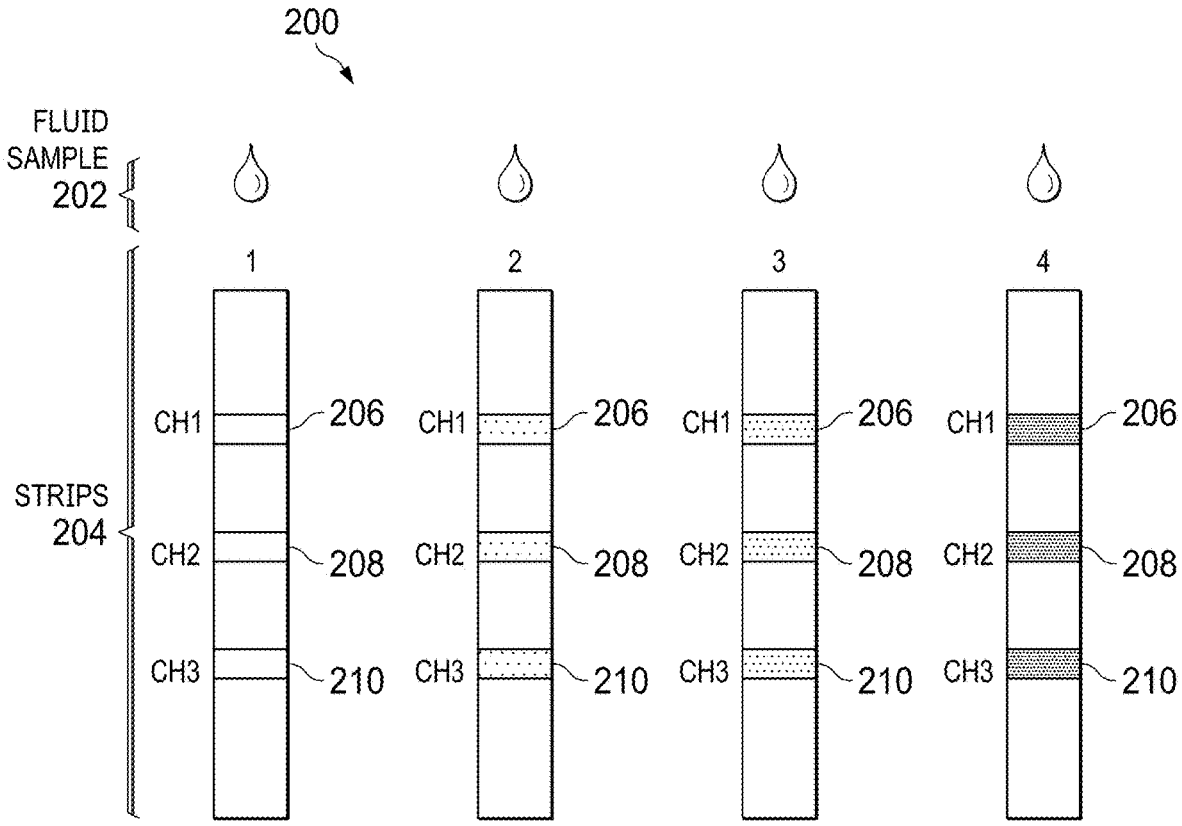


FIG. 2

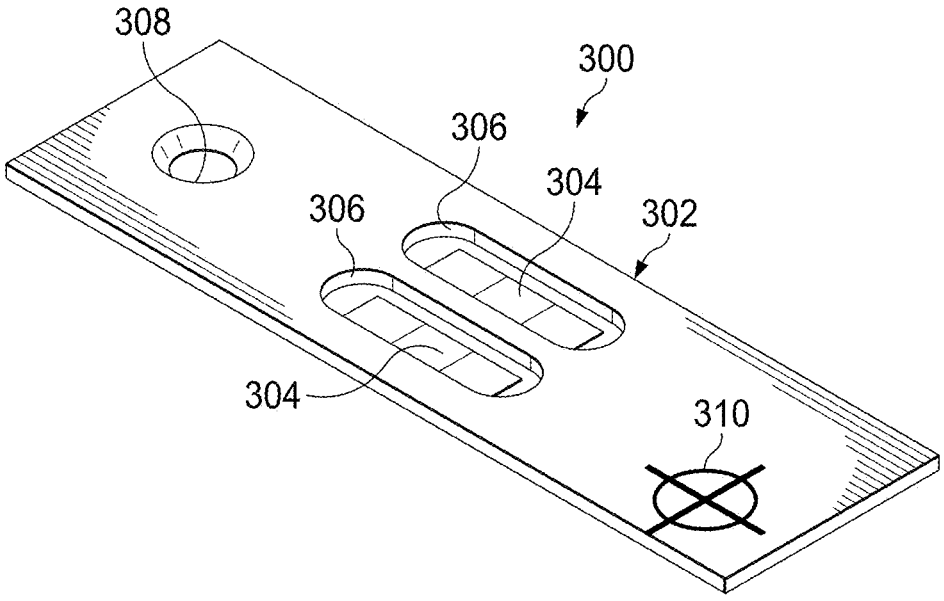


FIG. 3

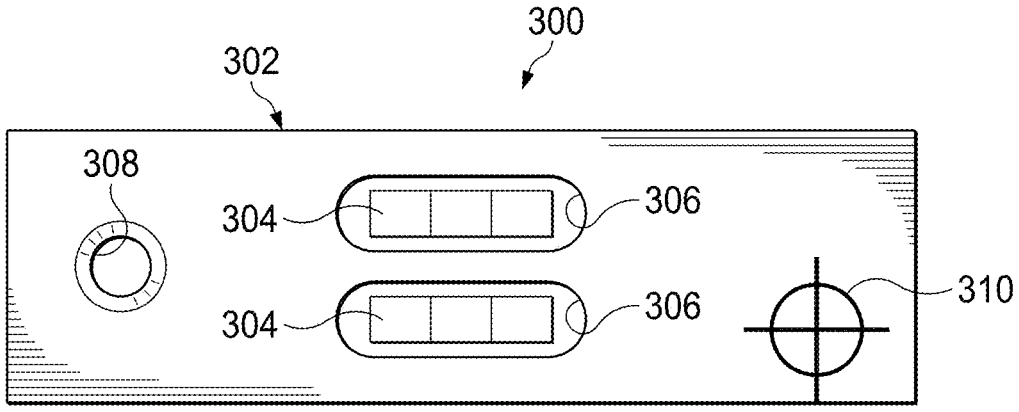


FIG. 4

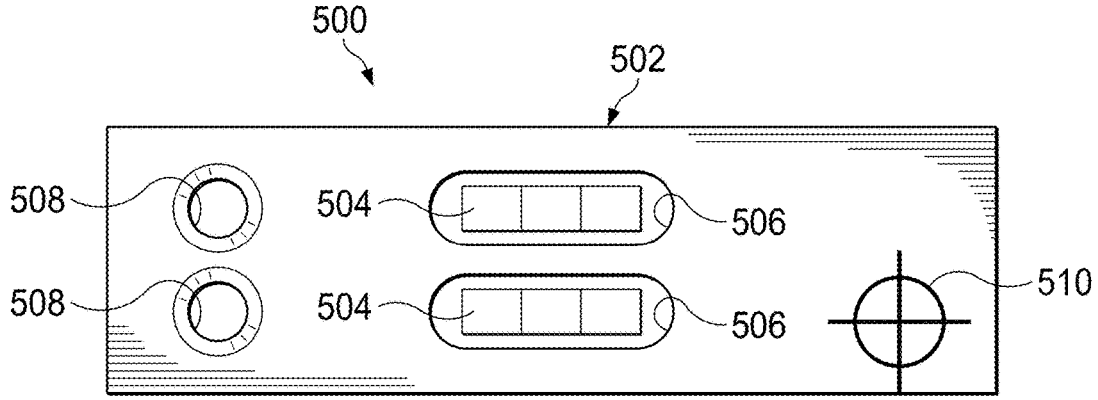

500
502
508
504
506
508
504
506
510

FIG. 5

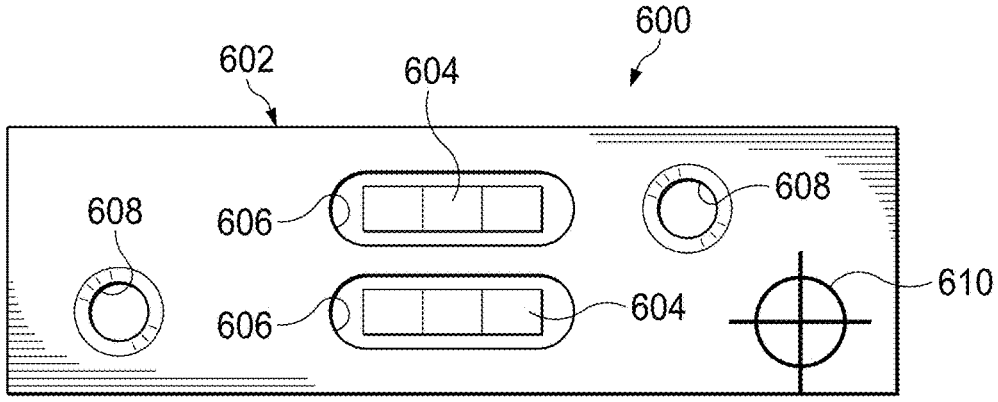

600
602
604
608
606
608
606
604
610

FIG. 6

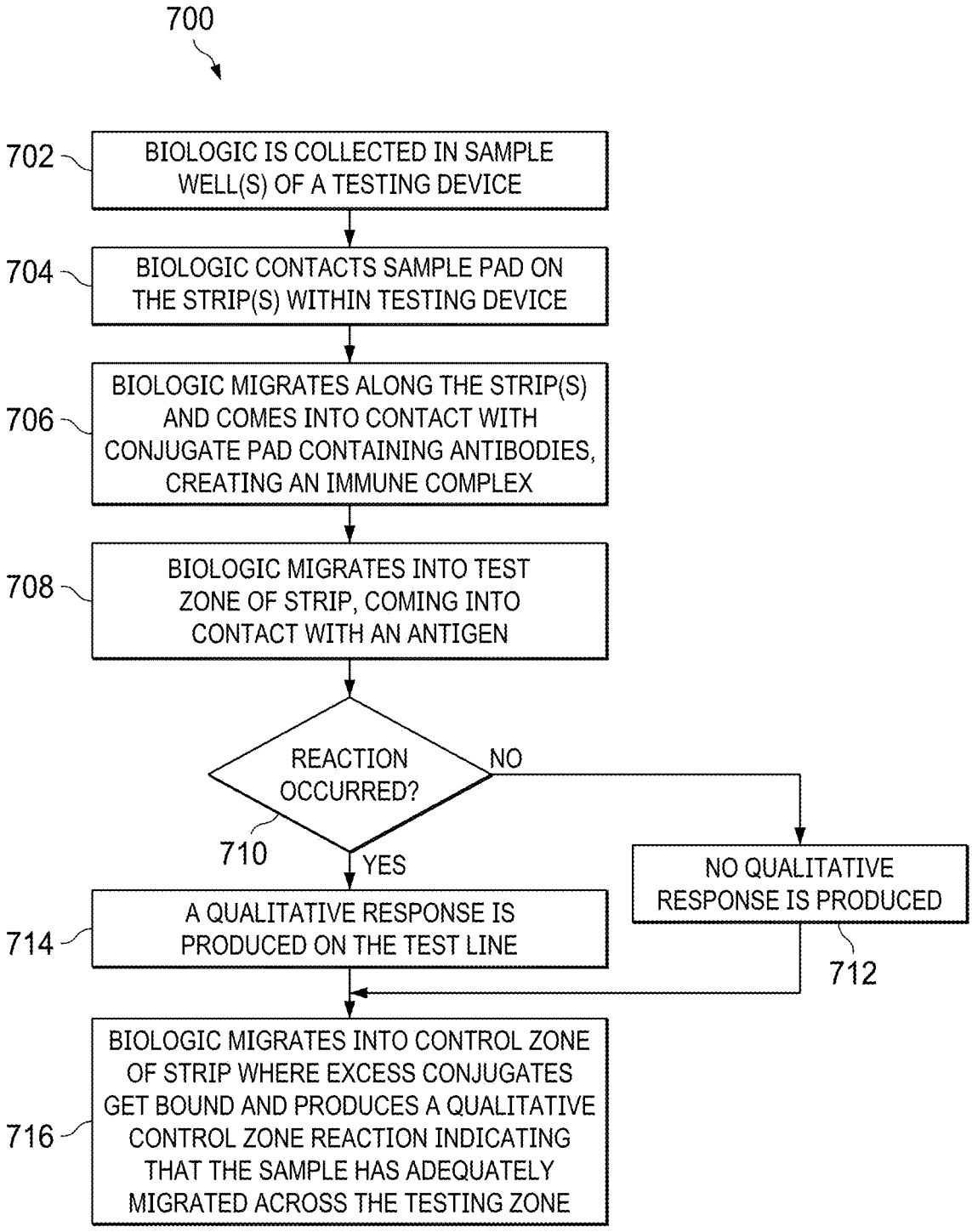

700
702
BIOLOGIC IS COLLECTED IN SAMPLE WELL(S) OF A TESTING DEVICE
704
BIOLOGIC CONTACTS SAMPLE PAD ON THE STRIP(S) WITHIN TESTING DEVICE
706
BIOLOGIC MIGRATES ALONG THE STRIP(S) AND COMES INTO CONTACT WITH CONJUGATE PAD CONTAINING ANTIBODIES, CREATING AN IMMUNE COMPLEX
708
BIOLOGIC MIGRATES INTO TEST ZONE OF STRIP, COMING INTO CONTACT WITH AN ANTIGEN
REACTION OCCURRED?
710
NO
YES
NO QUALITATIVE RESPONSE IS PRODUCED
712
714
A QUALITATIVE RESPONSE IS PRODUCED ON THE TEST LINE
716
BIOLOGIC MIGRATES INTO CONTROL ZONE OF STRIP WHERE EXCESS CONJUGATES GET BOUND AND PRODUCES A QUALITATIVE CONTROL ZONE REACTION INDICATING THAT THE SAMPLE HAS ADEQUATELY MIGRATED ACROSS THE TESTING ZONE

FIG. 7

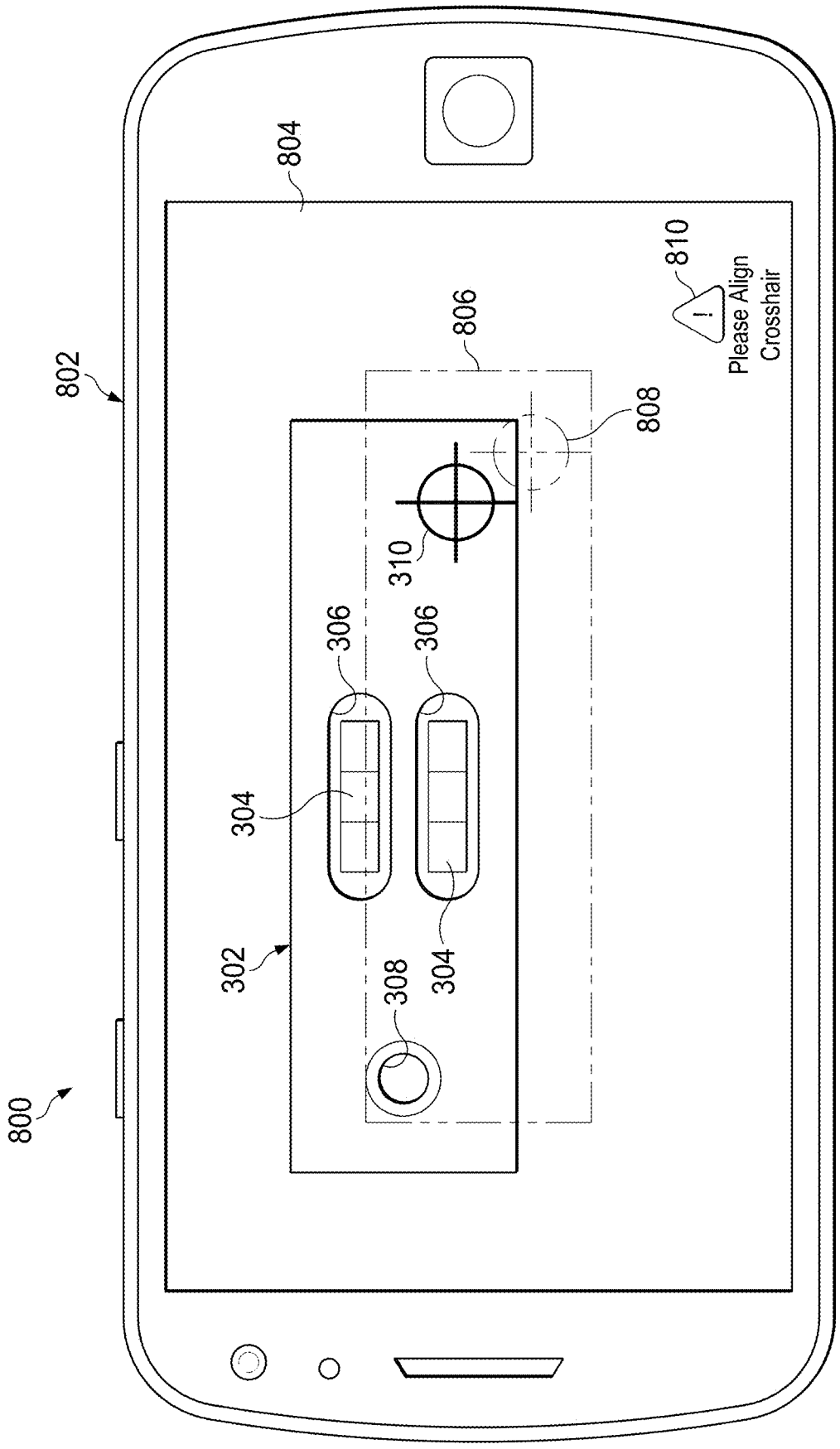

800
802
804
806
808
810
Please Align Crosshair
!
302
304
306
308
310

FIG. 8A

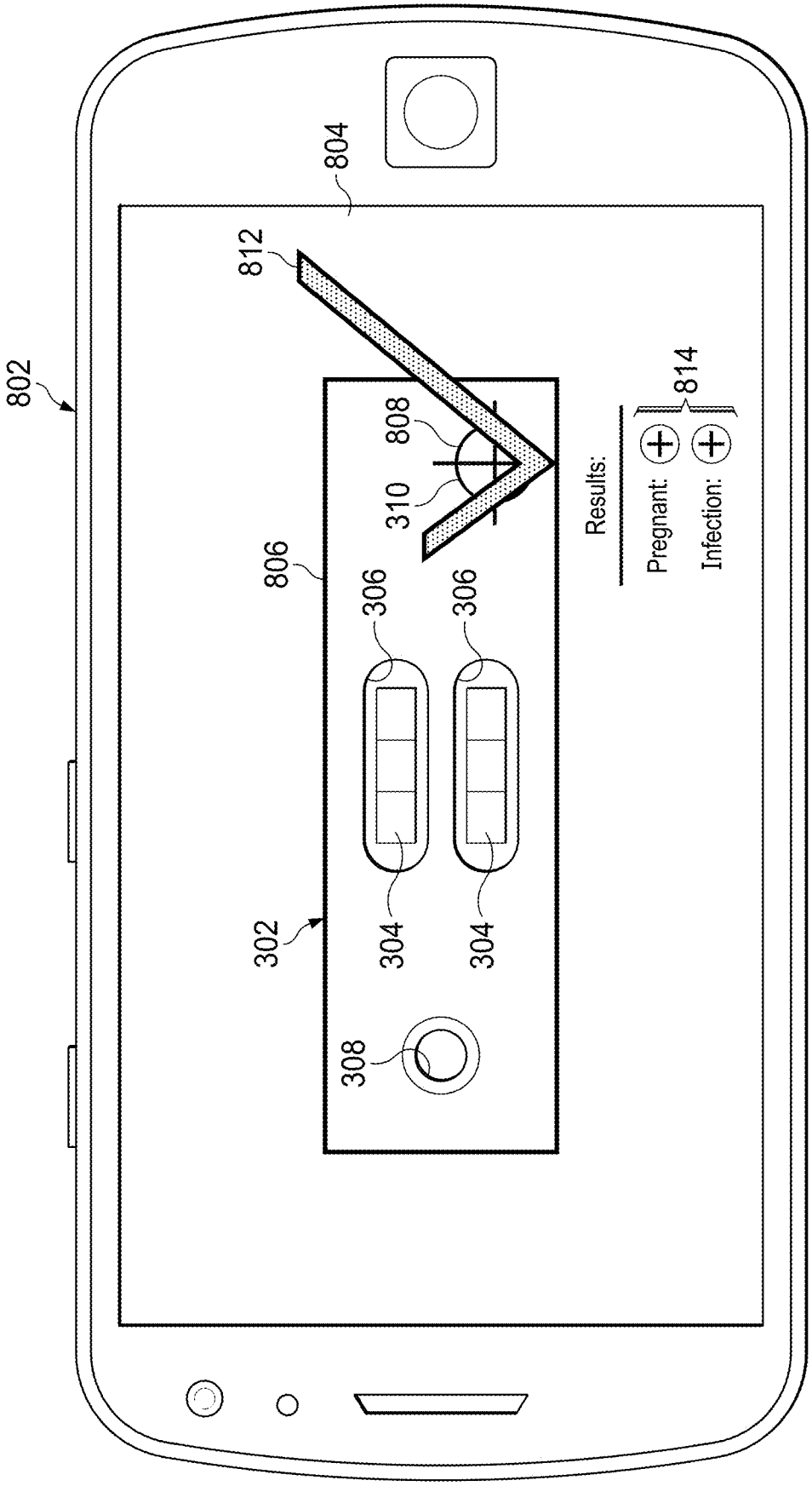

802
804
812
808
310
806
306
306
Results:
814
Pregnant:
Infection:
302
304
304
308

FIG. 8B

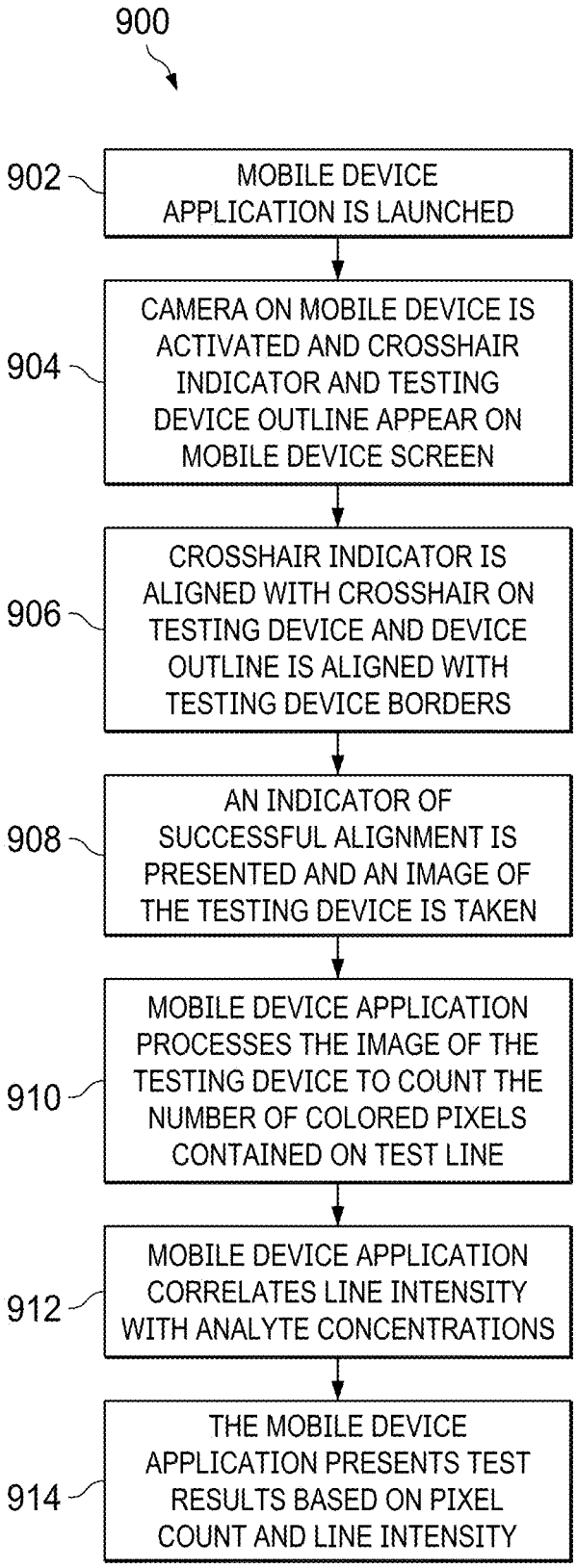

900
902
MOBILE DEVICE APPLICATION IS LAUNCHED
904
CAMERA ON MOBILE DEVICE IS ACTIVATED AND CROSSHAIR INDICATOR AND TESTING DEVICE OUTLINE APPEAR ON MOBILE DEVICE SCREEN
906
CROSSHAIR INDICATOR IS ALIGNED WITH CROSSHAIR ON TESTING DEVICE AND DEVICE OUTLINE IS ALIGNED WITH TESTING DEVICE BORDERS
908
AN INDICATOR OF SUCCESSFUL ALIGNMENT IS PRESENTED AND AN IMAGE OF THE TESTING DEVICE IS TAKEN
910
MOBILE DEVICE APPLICATION PROCESSES THE IMAGE OF THE TESTING DEVICE TO COUNT THE NUMBER OF COLORED PIXELS CONTAINED ON TEST LINE
912
MOBILE DEVICE APPLICATION CORRELATES LINE INTENSITY WITH ANALYTE CONCENTRATIONS
914
THE MOBILE DEVICE APPLICATION PRESENTS TEST RESULTS BASED ON PIXEL COUNT AND LINE INTENSITY

FIG. 9

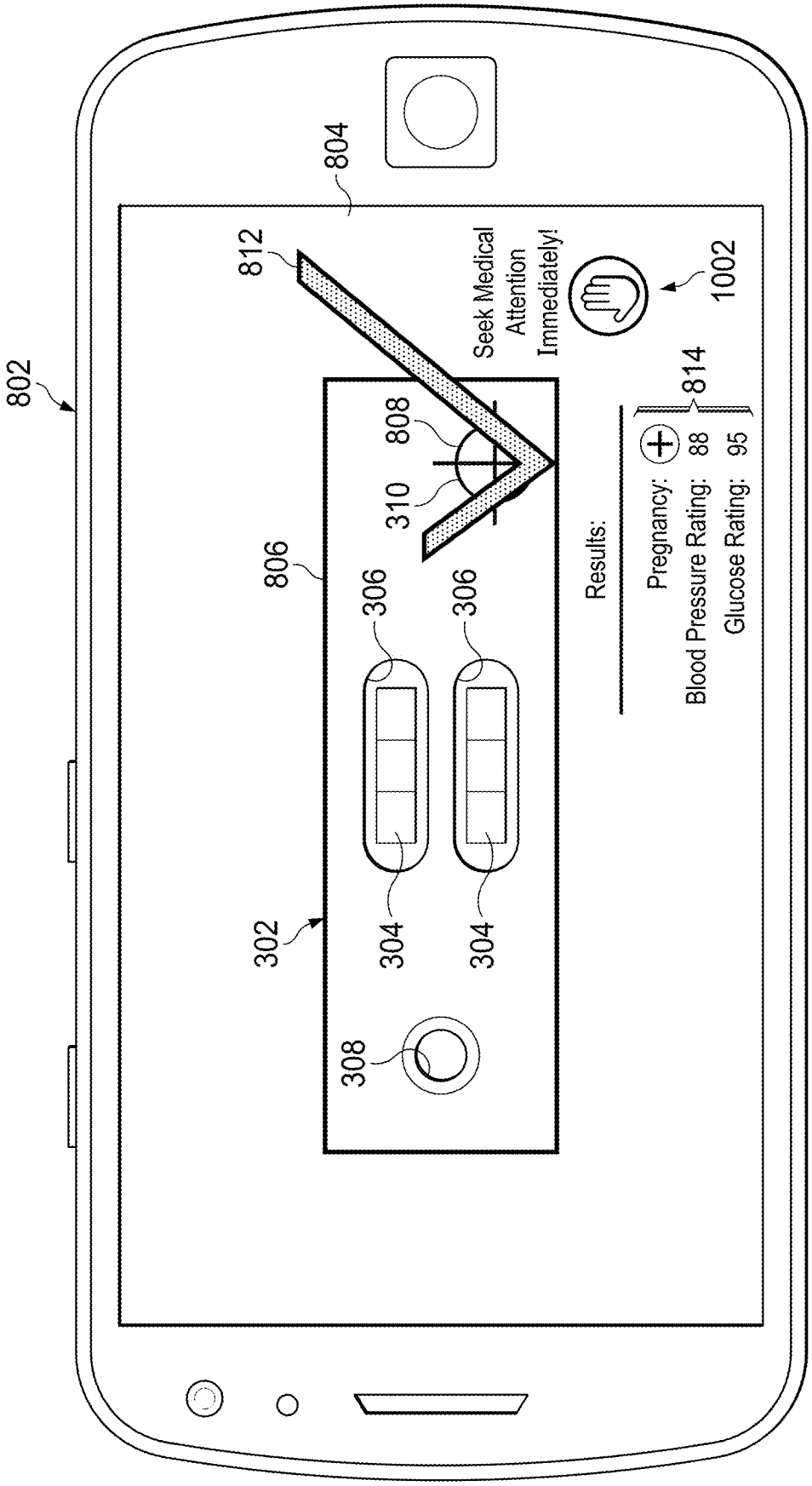

802
804
812
Seek Medical Attention Immediately!
1002
814
808
310
806
306
306
Results:
Pregnancy: +
Blood Pressure Rating: 88
Glucose Rating: 95
302
304
304
308

FIG. 10

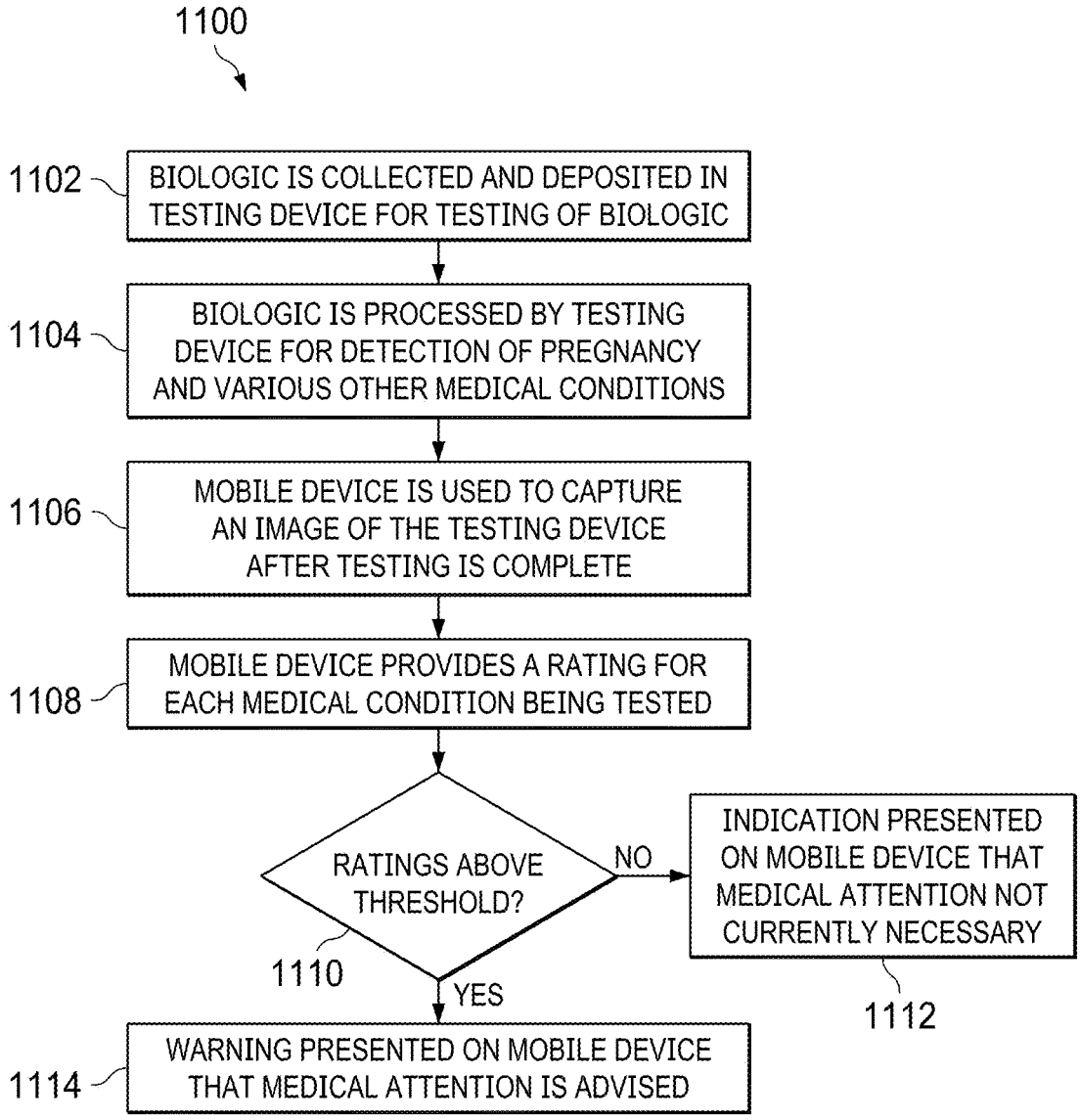

1100
1102
BIOLOGIC IS COLLECTED AND DEPOSITED IN TESTING DEVICE FOR TESTING OF BIOLOGIC
1104
BIOLOGIC IS PROCESSED BY TESTING DEVICE FOR DETECTION OF PREGNANCY AND VARIOUS OTHER MEDICAL CONDITIONS
1106
MOBILE DEVICE IS USED TO CAPTURE AN IMAGE OF THE TESTING DEVICE AFTER TESTING IS COMPLETE
1108
MOBILE DEVICE PROVIDES A RATING FOR EACH MEDICAL CONDITION BEING TESTED
RATINGS ABOVE THRESHOLD?
1110
NO
YES
INDICATION PRESENTED ON MOBILE DEVICE THAT MEDICAL ATTENTION NOT CURRENTLY NECESSARY
1112
1114
WARNING PRESENTED ON MOBILE DEVICE THAT MEDICAL ATTENTION IS ADVISED

FIG. 11

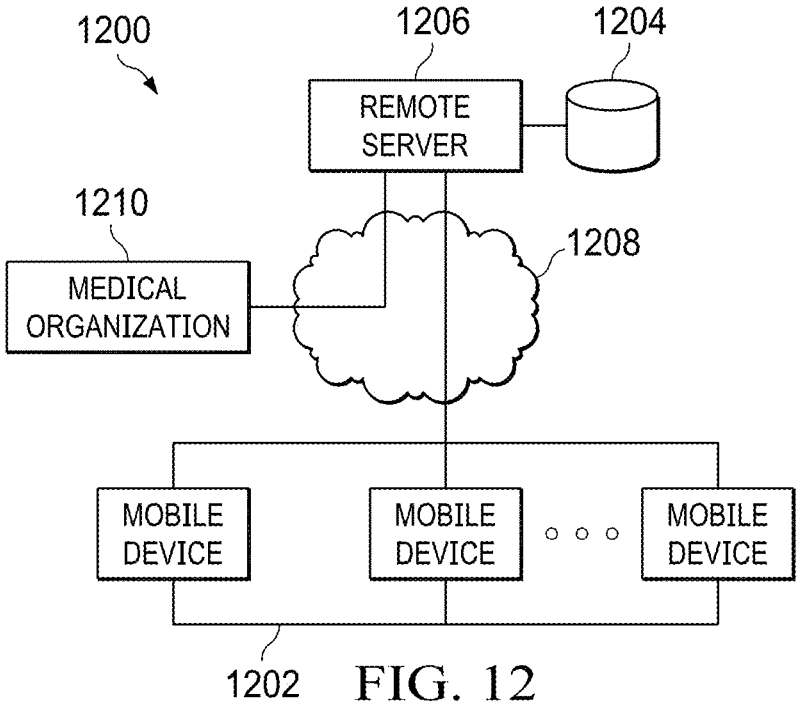


FIG. 12

1300

BIOLOGIC ID # 2402		1302
BIOLOGIC TYPE	BLOOD	1304
PREGNANCY RATING	99	1304
ZIKA INFECTION RATING	75	1304
GLUCOSE RATING	10	1304

FIG. 13

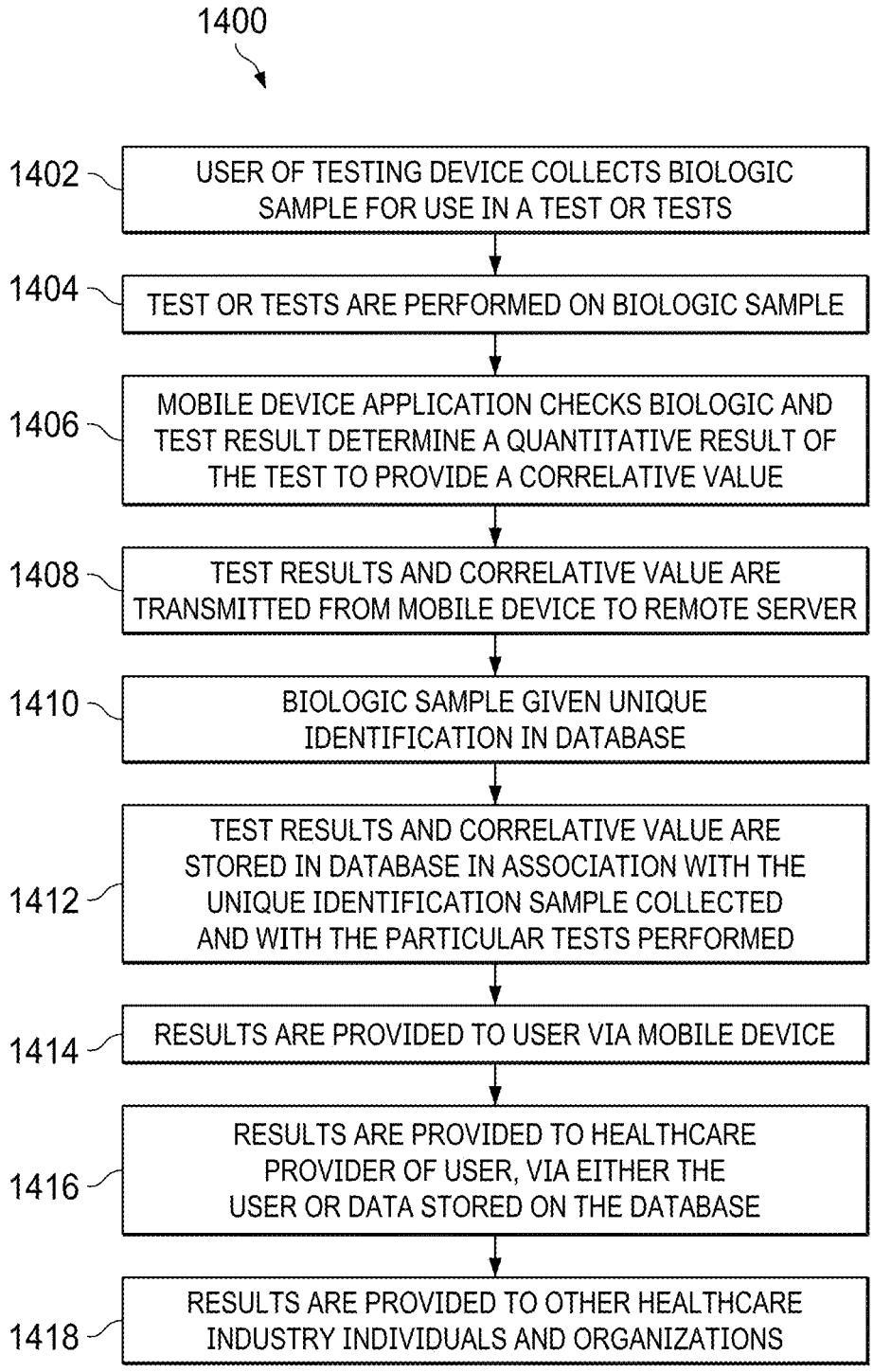

1400
1402
USER OF TESTING DEVICE COLLECTS BIOLOGIC SAMPLE FOR USE IN A TEST OR TESTS
1404
TEST OR TESTS ARE PERFORMED ON BIOLOGIC SAMPLE
1406
MOBILE DEVICE APPLICATION CHECKS BIOLOGIC AND TEST RESULT DETERMINE A QUANTITATIVE RESULT OF THE TEST TO PROVIDE A CORRELATIVE VALUE
1408
TEST RESULTS AND CORRELATIVE VALUE ARE TRANSMITTED FROM MOBILE DEVICE TO REMOTE SERVER
1410
BIOLOGIC SAMPLE GIVEN UNIQUE IDENTIFICATION IN DATABASE
1412
TEST RESULTS AND CORRELATIVE VALUE ARE STORED IN DATABASE IN ASSOCIATION WITH THE UNIQUE IDENTIFICATION SAMPLE COLLECTED AND WITH THE PARTICULAR TESTS PERFORMED
1414
RESULTS ARE PROVIDED TO USER VIA MOBILE DEVICE
1416
RESULTS ARE PROVIDED TO HEALTHCARE PROVIDER OF USER, VIA EITHER THE USER OR DATA STORED ON THE DATABASE
1418
RESULTS ARE PROVIDED TO OTHER HEALTHCARE INDUSTRY INDIVIDUALS AND ORGANIZATIONS

FIG. 14

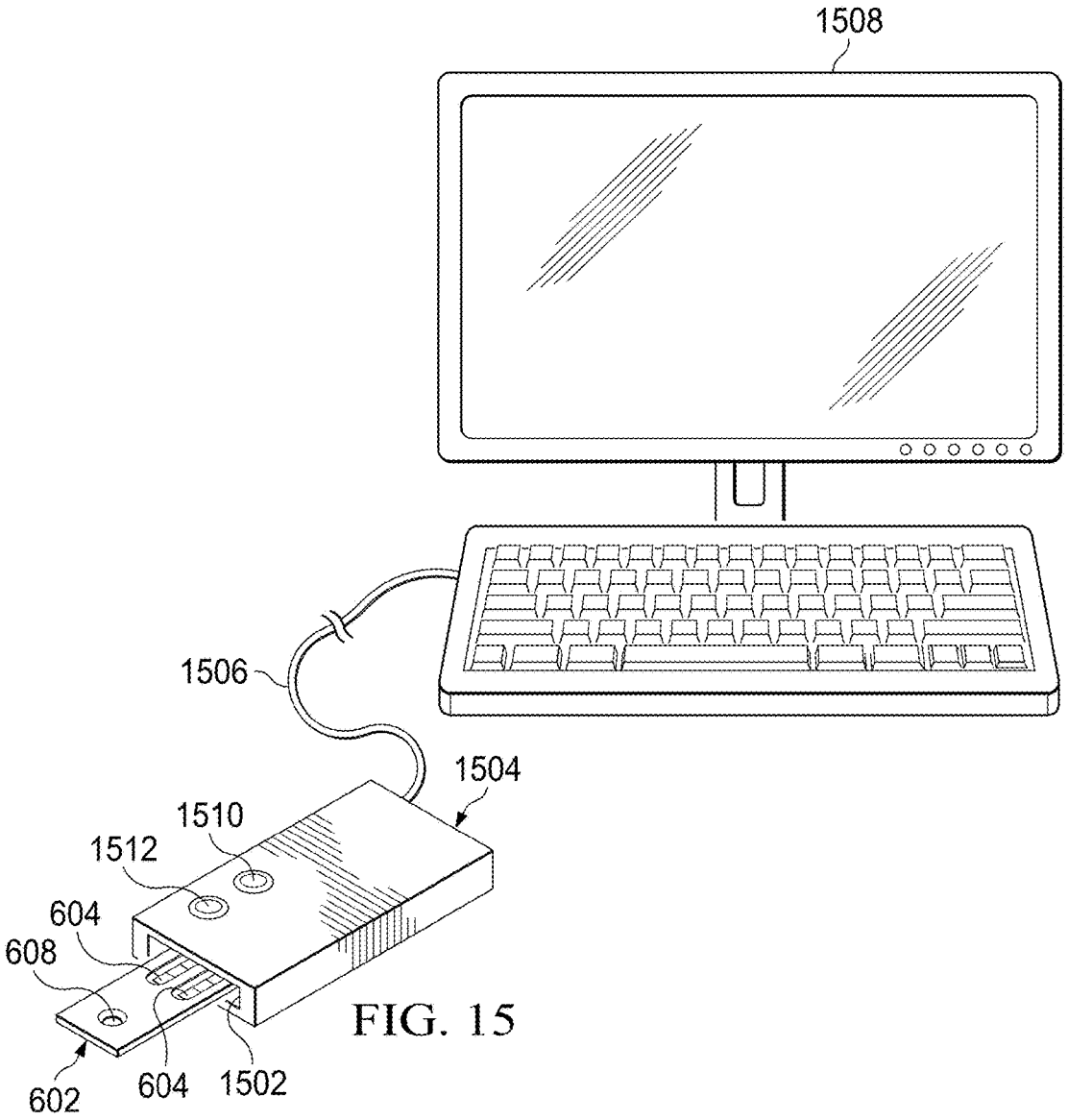

1508
1506
1504
1510
1512
604
608
602
604
1502

FIG. 15

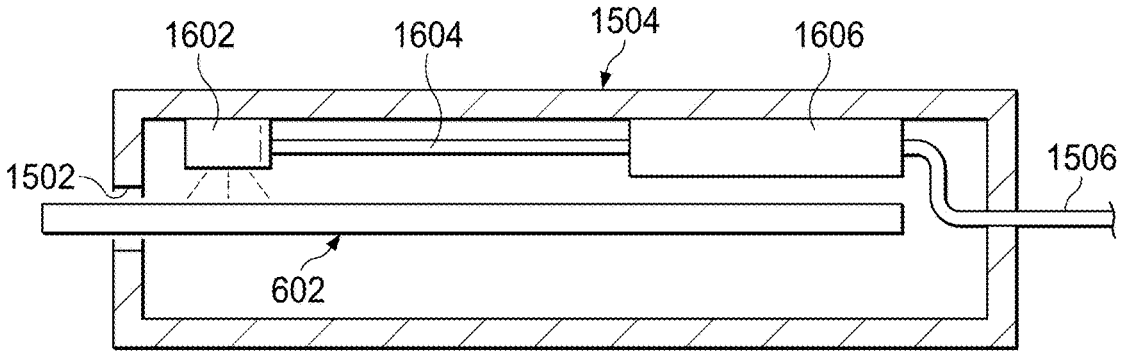

1602
1604
1504
1606
1502
1506
602

FIG. 16

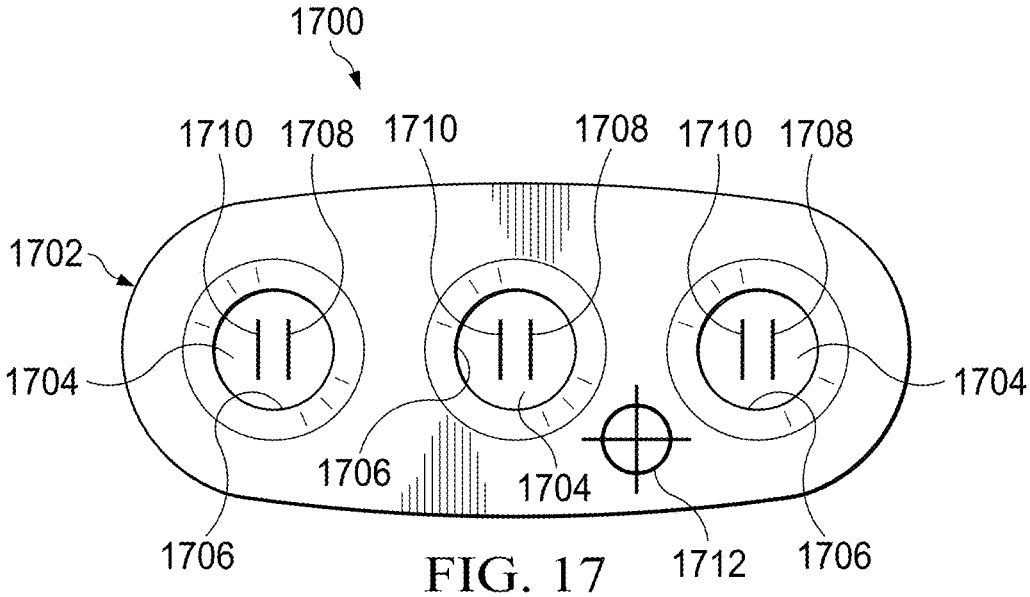

1700
1710
1708
1710
1708
1710
1708
1702
1704
1704
1706
1704
1706
1712
1706

FIG. 17

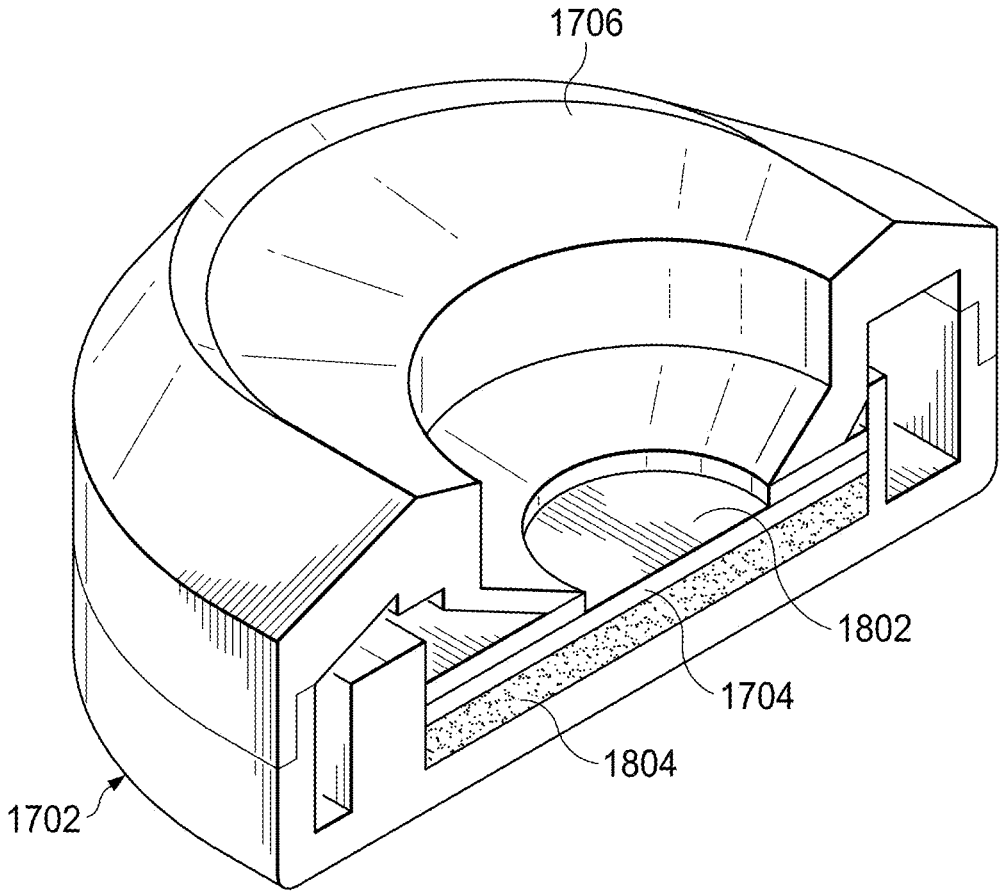

1706
1802
1704
1804
1702

FIG. 18

FIG. 19

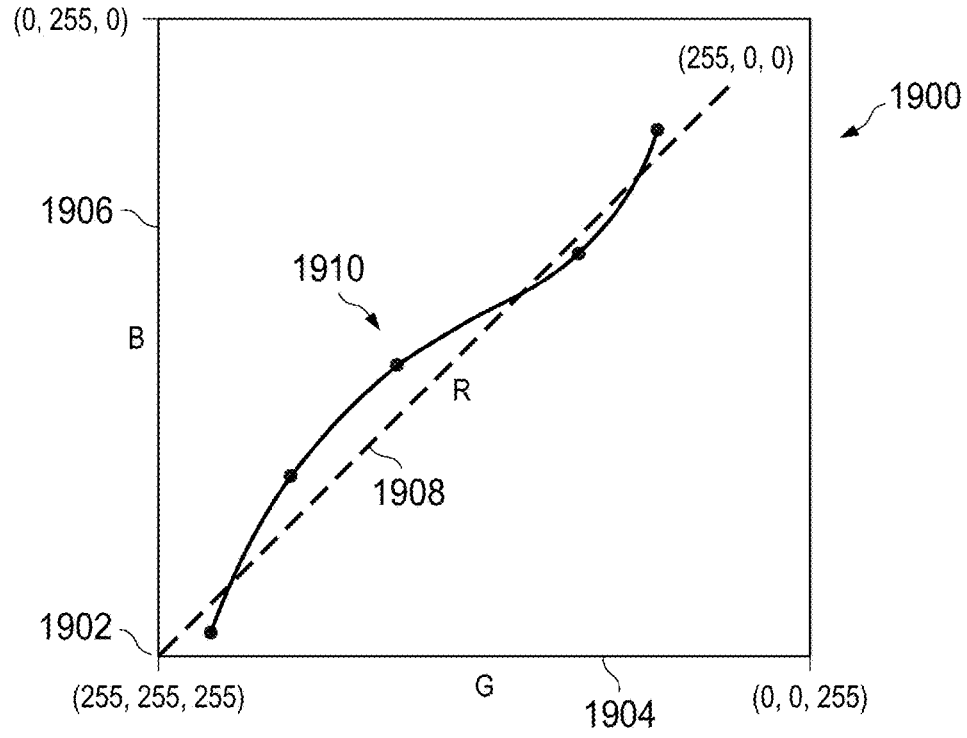
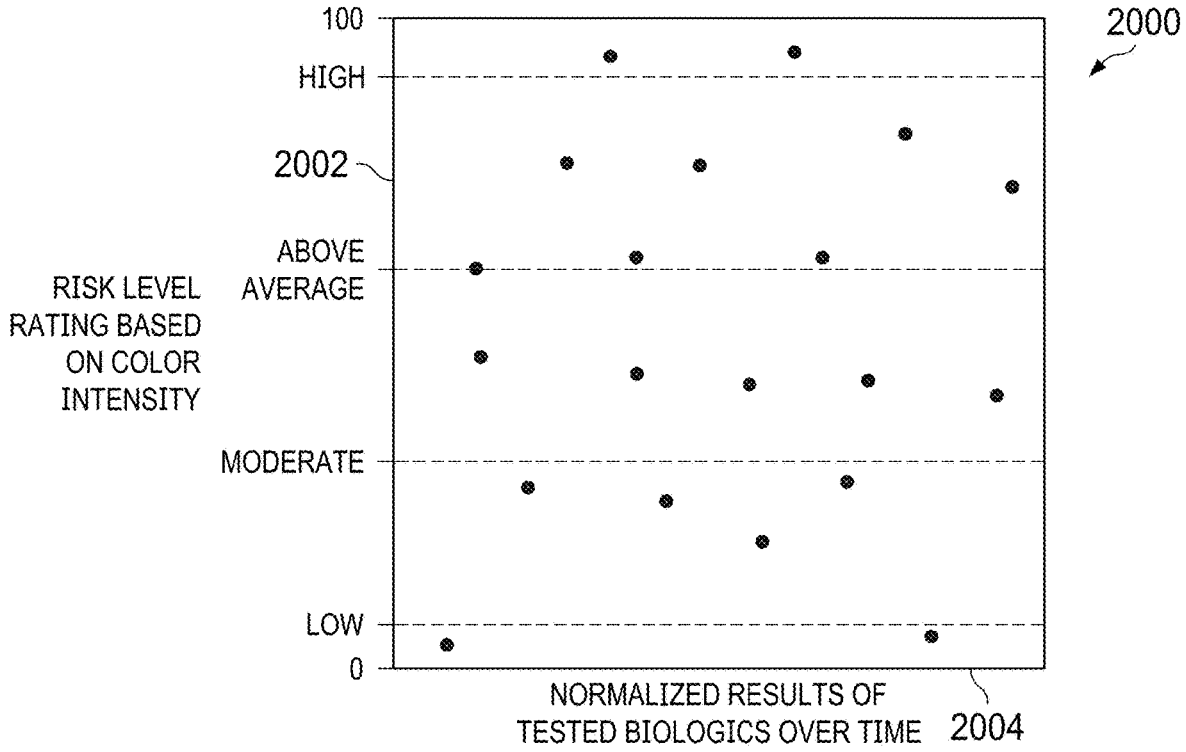

(0, 255, 0)
(255, 0, 0)
1900
1906
1910
B
R
1908
1902
(255, 255, 255)
G
1904
(0, 0, 255)

FIG. 20


100
HIGH
2000
2002
ABOVE AVERAGE
RISK LEVEL RATING BASED ON COLOR INTENSITY
MODERATE
LOW
0
NORMALIZED RESULTS OF TESTED BIOLOGICS OVER TIME
2004

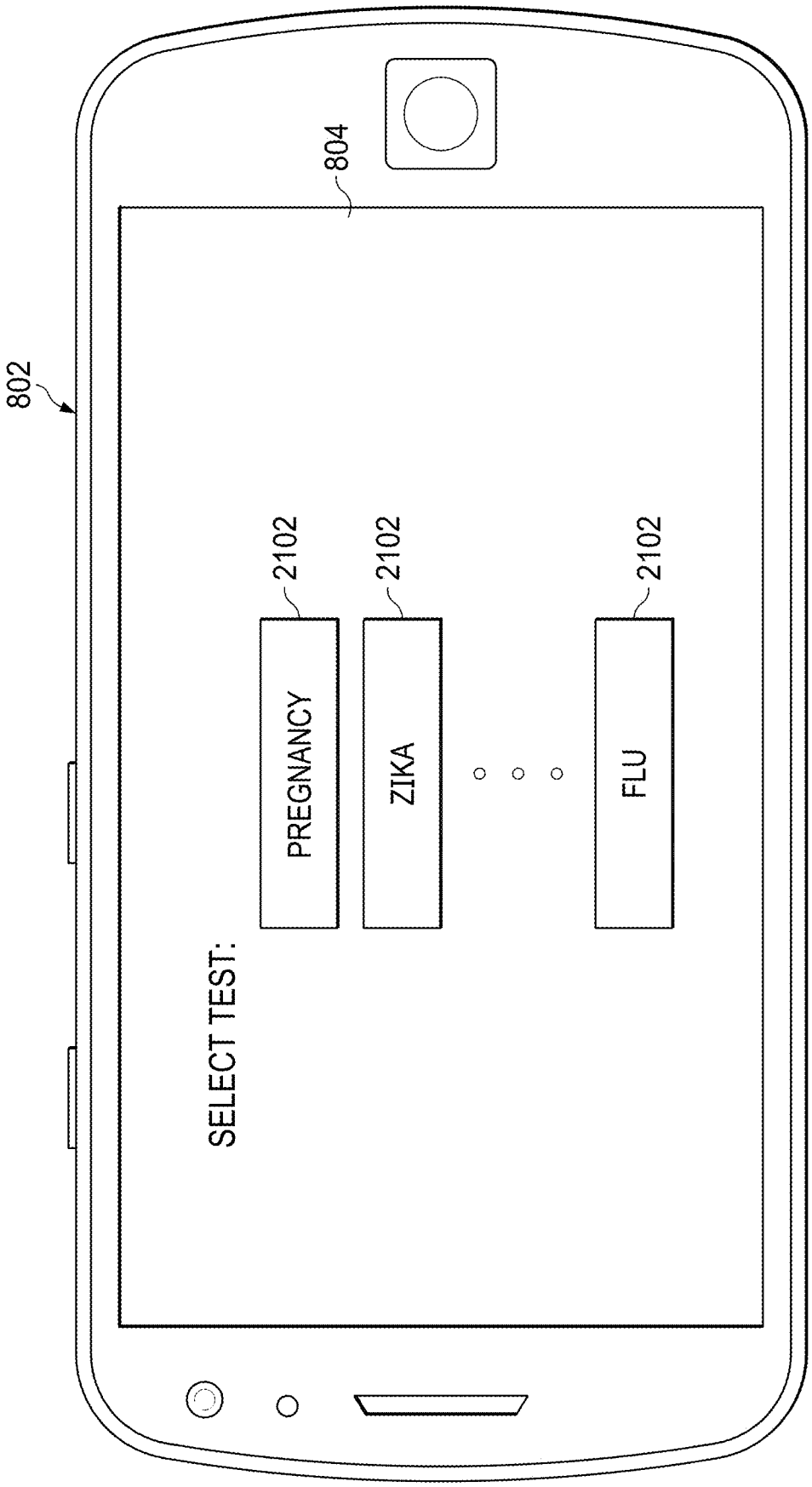


FIG. 21

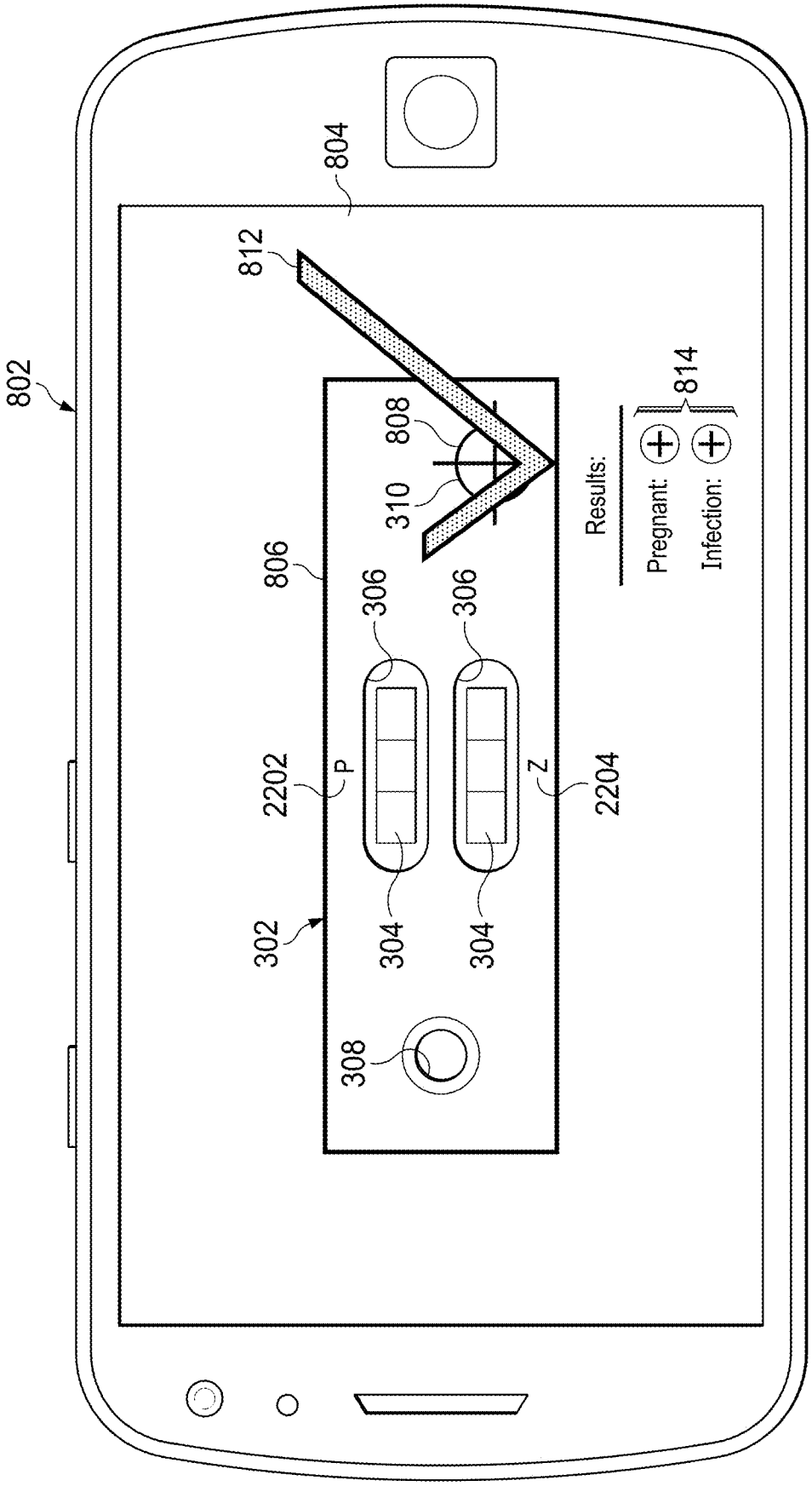

802
804
812
808
310
806
306
306
Results:
814
Pregnant:
Infection:
2202
P
Z
2204
302
304
304
308

FIG. 22

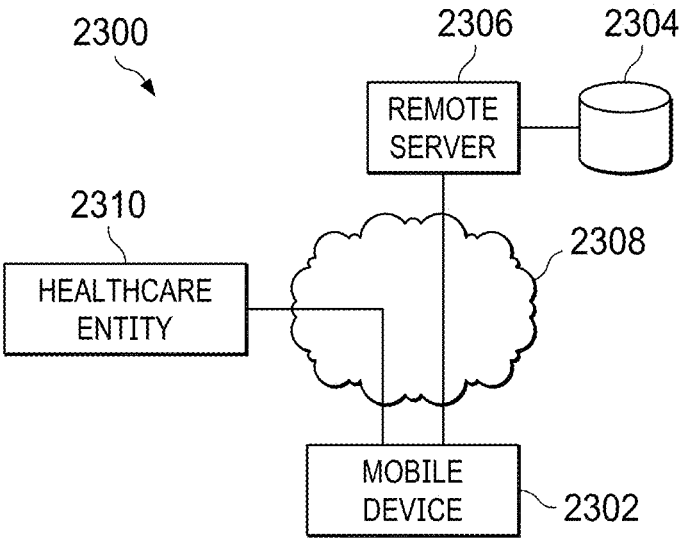


FIG. 23

2400

STREP HOME RETAIL TEST	
DIAGNOSIS CODE	J02.0
HCPCS CODE	G0435
PHARMACY CODE	NDC 54569-5182-0

FIG. 24

2500

PREGNANCY AND ZIKA HOME RETAIL TEST		
	PREGNANCY	ZIKA
DIAGNOSIS CODE	Z33.1	A92.5
HCPCS CODE	G8802	G0435
PHARMACY CODE	NDC 42192-321-30	NDC 50580-501-30

FIG. 25

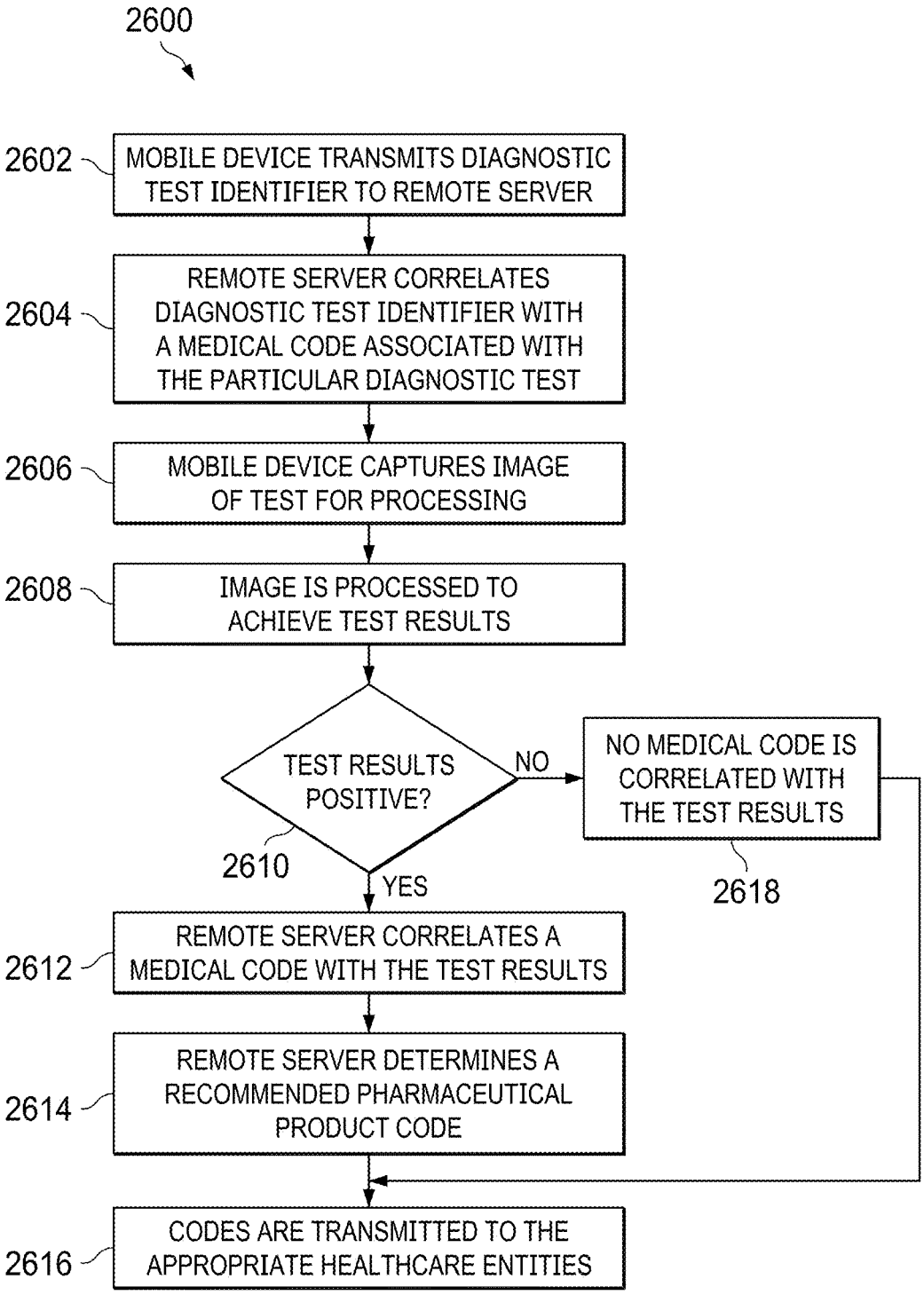

2600
2602
MOBILE DEVICE TRANSMITS DIAGNOSTIC TEST IDENTIFIER TO REMOTE SERVER
2604
REMOTE SERVER CORRELATES DIAGNOSTIC TEST IDENTIFIER WITH A MEDICAL CODE ASSOCIATED WITH THE PARTICULAR DIAGNOSTIC TEST
2606
MOBILE DEVICE CAPTURES IMAGE OF TEST FOR PROCESSING
2608
IMAGE IS PROCESSED TO ACHIEVE TEST RESULTS
TEST RESULTS POSITIVE?
2610
NO
NO MEDICAL CODE IS CORRELATED WITH THE TEST RESULTS
2618
YES
2612
REMOTE SERVER CORRELATES A MEDICAL CODE WITH THE TEST RESULTS
2614
REMOTE SERVER DETERMINES A RECOMMENDED PHARMACEUTICAL PRODUCT CODE
2616
CODES ARE TRANSMITTED TO THE APPROPRIATE HEALTHCARE ENTITIES

FIG. 26

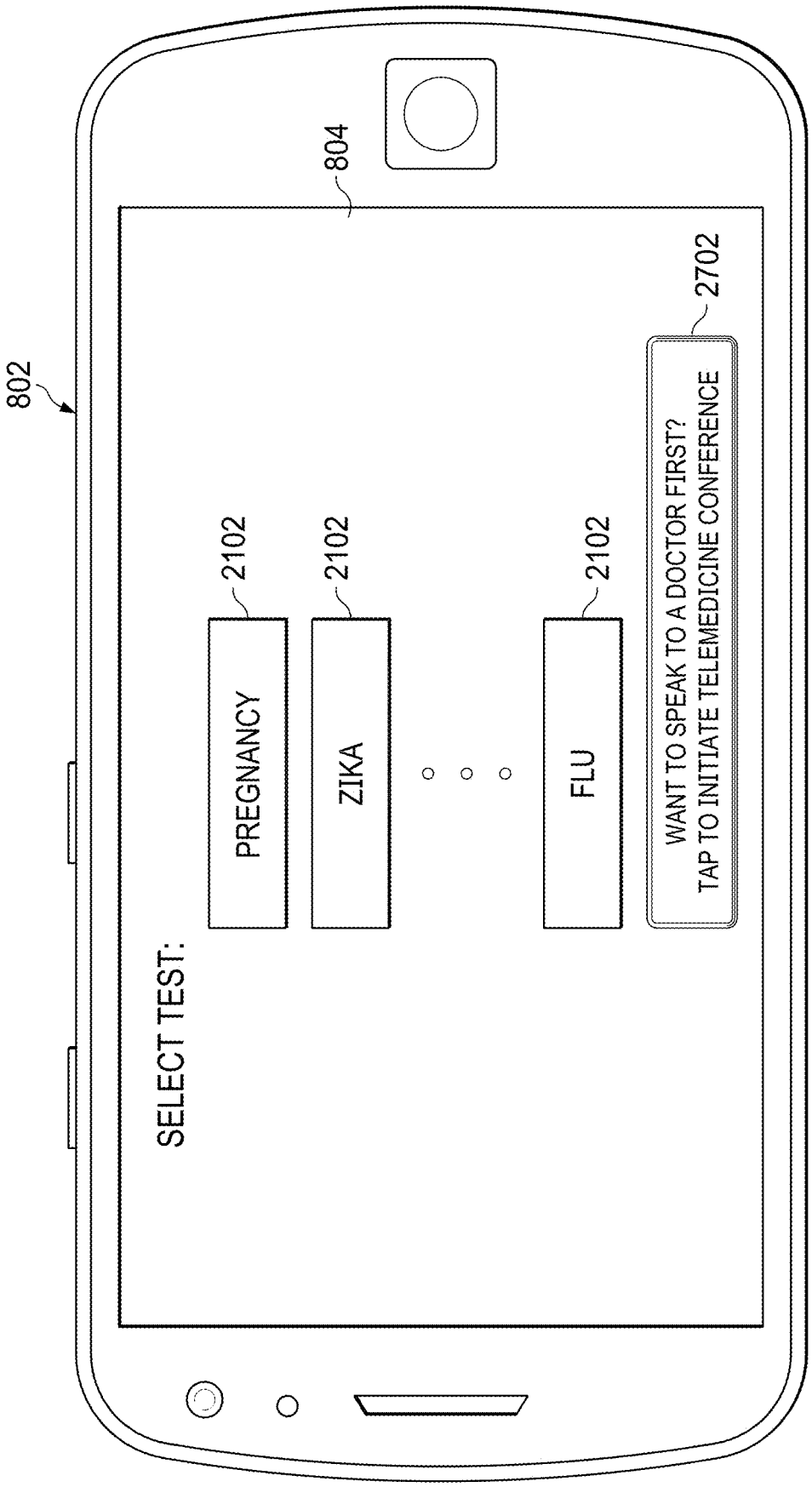

802
804
SELECT TEST:
PREGNANCY
2102
ZIKA
2102
FLU
2102
WANT TO SPEAK TO A DOCTOR FIRST?
TAP TO INITIATE TELEMEDICINE CONFERENCE
2702

FIG. 27

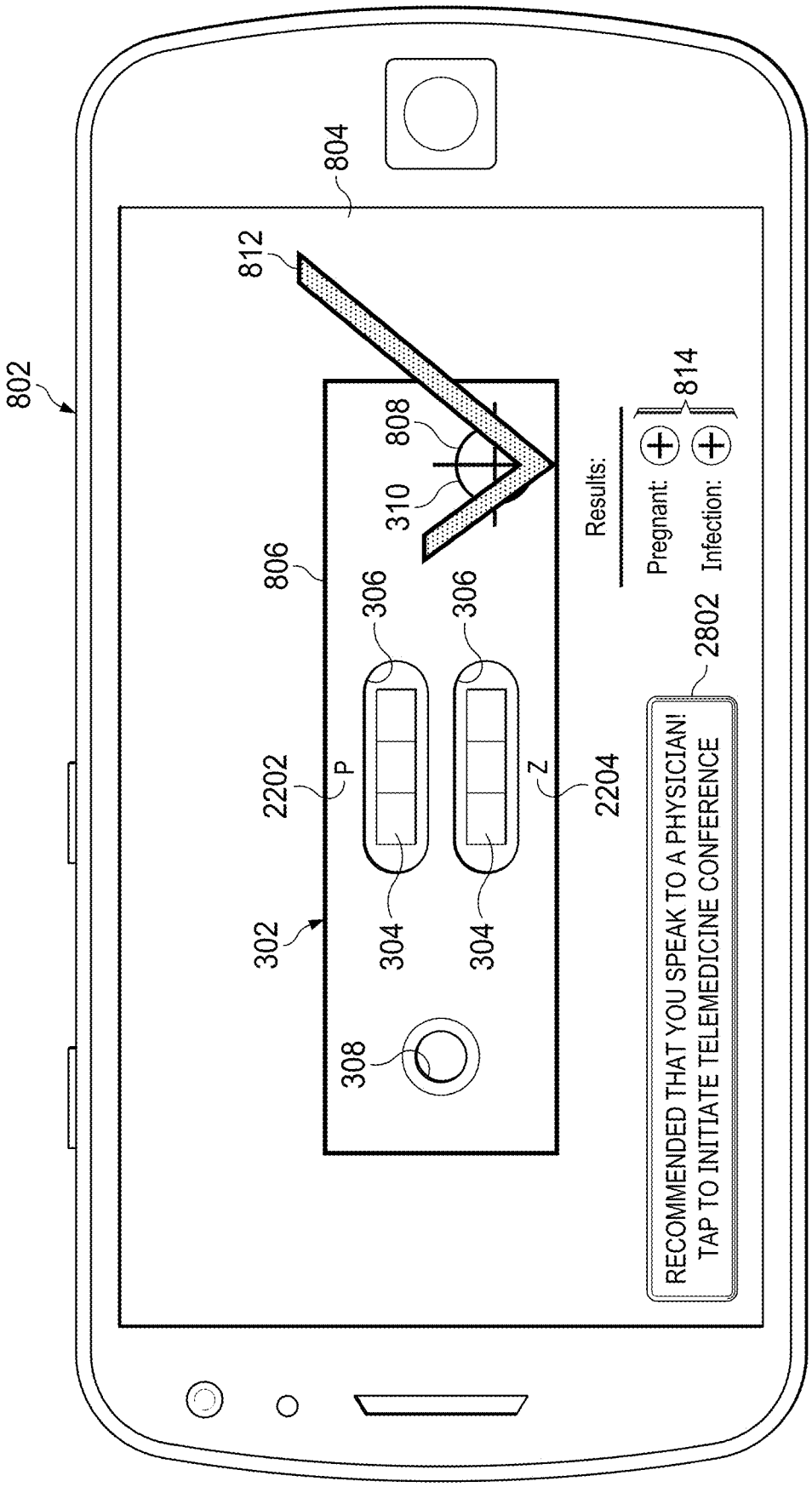

802
804
812
808
310
806
306
306
Results:
814
Pregnant:
Infection:
2802
2202
P
Z
2204
302
304
304
308
RECOMMENDED THAT YOU SPEAK TO A PHYSICIAN!
TAP TO INITIATE TELEMEDICINE CONFERENCE

FIG. 28

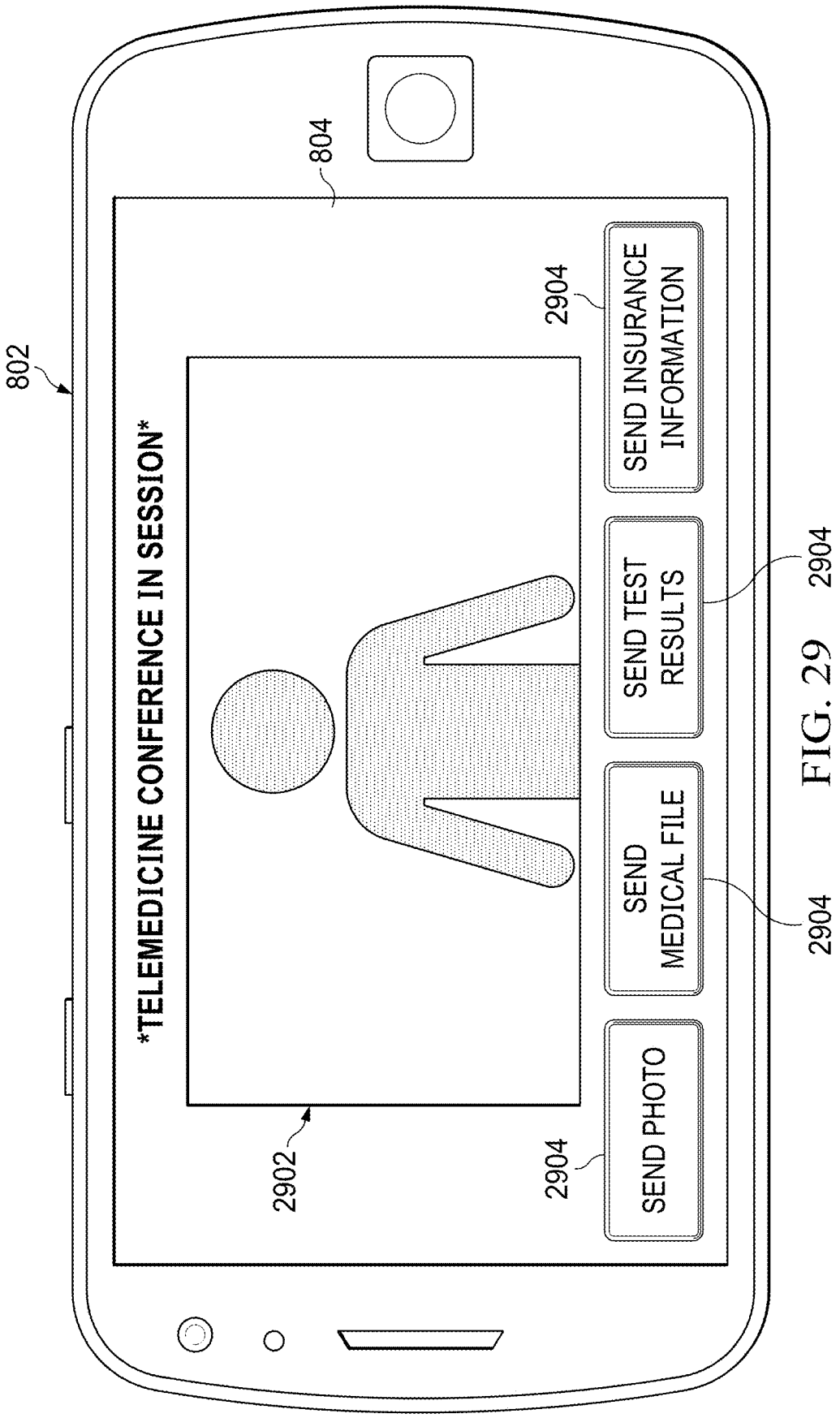

802
804
TELEMEDICINE CONFERENCE IN SESSION
2902
2904
SEND PHOTO
2904
SEND MEDICAL FILE
2904
SEND TEST RESULTS
2904
SEND INSURANCE INFORMATION

FIG. 29

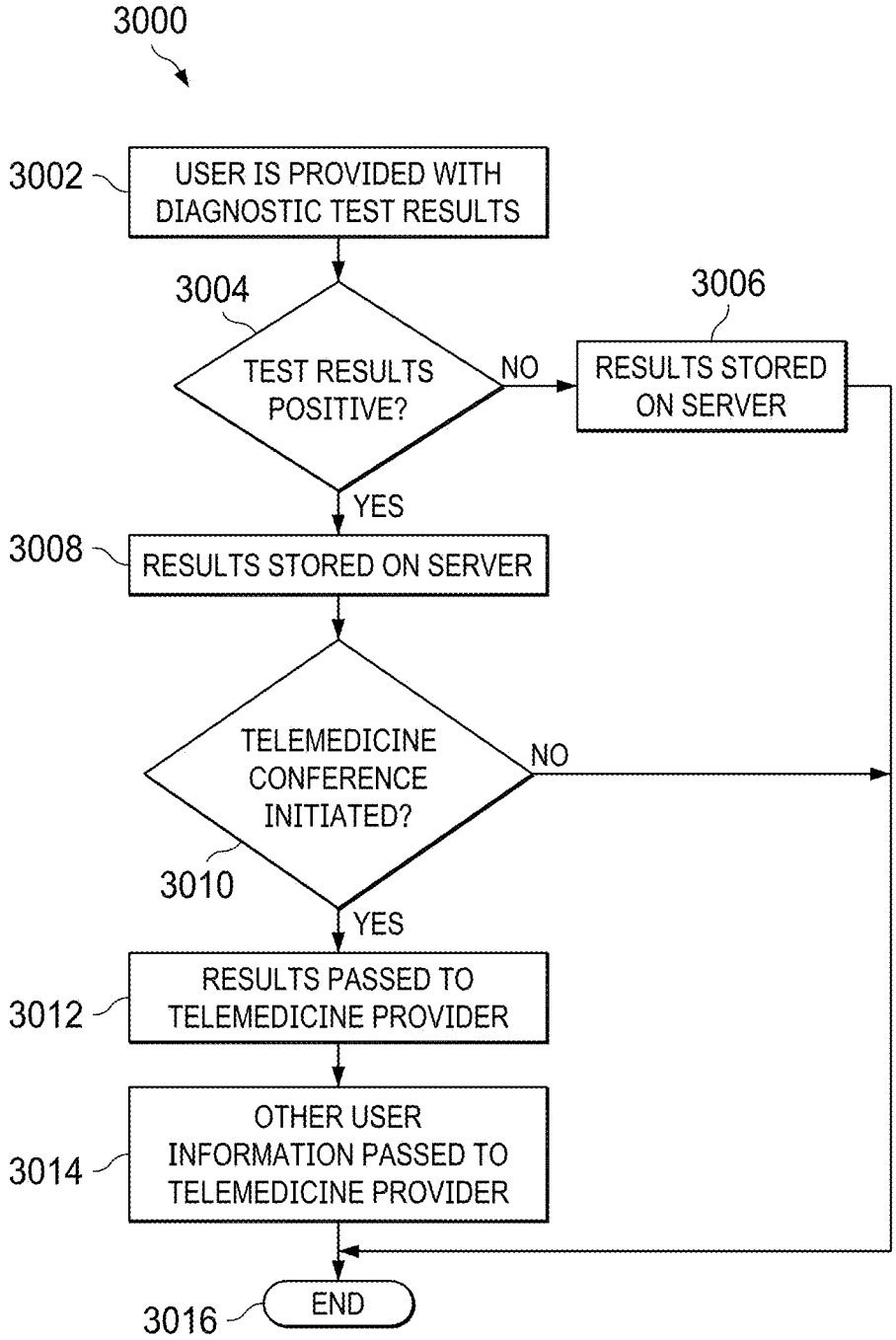

3000
3002
USER IS PROVIDED WITH DIAGNOSTIC TEST RESULTS
3004
TEST RESULTS POSITIVE?
NO
3006
RESULTS STORED ON SERVER
YES
3008
RESULTS STORED ON SERVER
TELEMEDICINE CONFERENCE INITIATED?
NO
3010
YES
3012
RESULTS PASSED TO TELEMEDICINE PROVIDER
3014
OTHER USER INFORMATION PASSED TO TELEMEDICINE PROVIDER
3016
END

FIG. 30

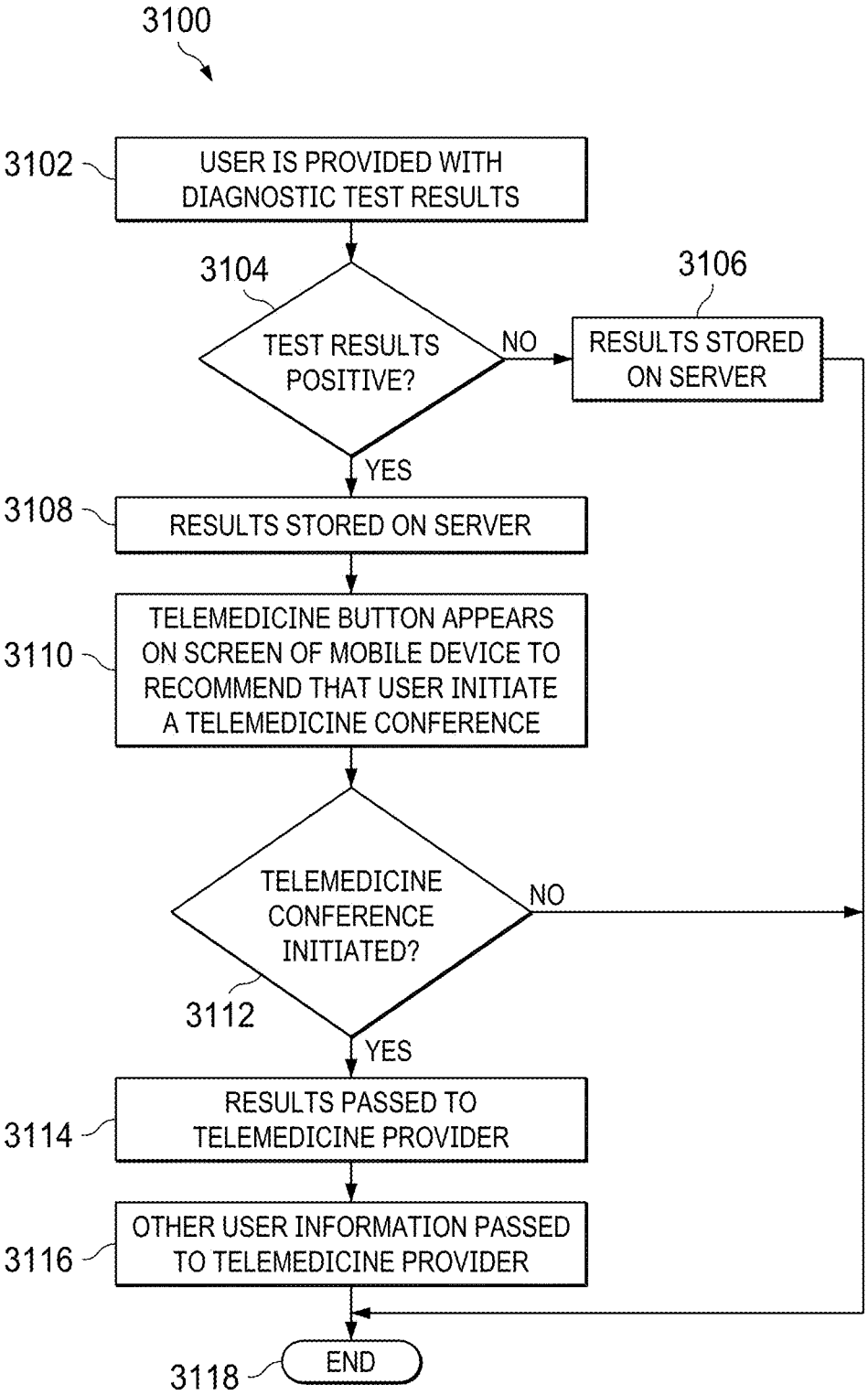

3100
3102
USER IS PROVIDED WITH DIAGNOSTIC TEST RESULTS
3104
TEST RESULTS POSITIVE?
NO
3106
RESULTS STORED ON SERVER
YES
3108
RESULTS STORED ON SERVER
3110
TELEMEDICINE BUTTON APPEARS ON SCREEN OF MOBILE DEVICE TO RECOMMEND THAT USER INITIATE A TELEMEDICINE CONFERENCE
TELEMEDICINE CONFERENCE INITIATED?
NO
3112
YES
3114
RESULTS PASSED TO TELEMEDICINE PROVIDER
3116
OTHER USER INFORMATION PASSED TO TELEMEDICINE PROVIDER
3118
END

FIG. 31

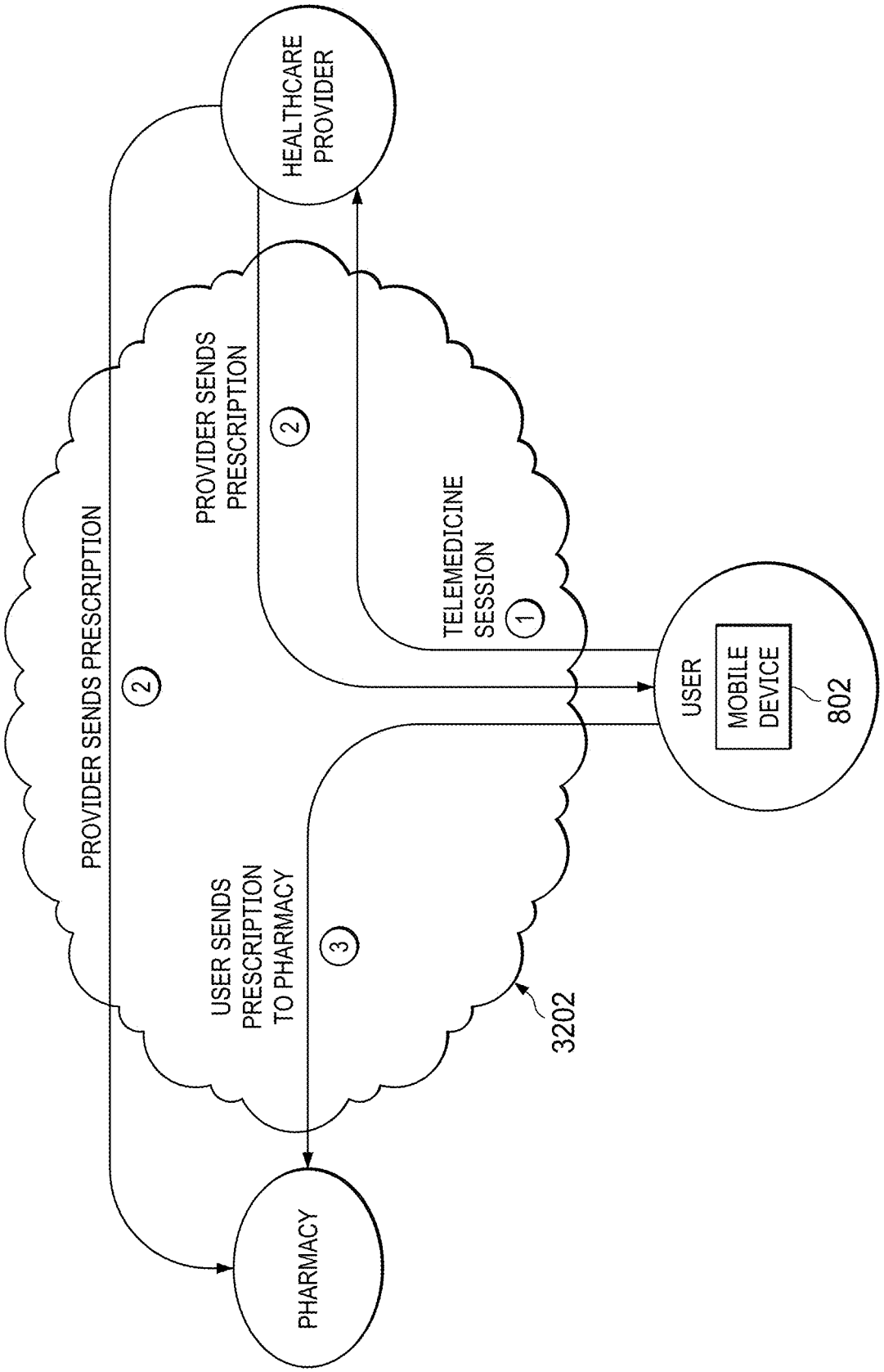

HEALTHCARE PROVIDER
PROVIDER SENDS PRESCRIPTION
2
PROVIDER SENDS PRESCRIPTION
2
TELEMEDICINE SESSION
1
USER
MOBILE DEVICE
802
USER SENDS PRESCRIPTION TO PHARMACY
3
3202
PHARMACY

FIG. 32A

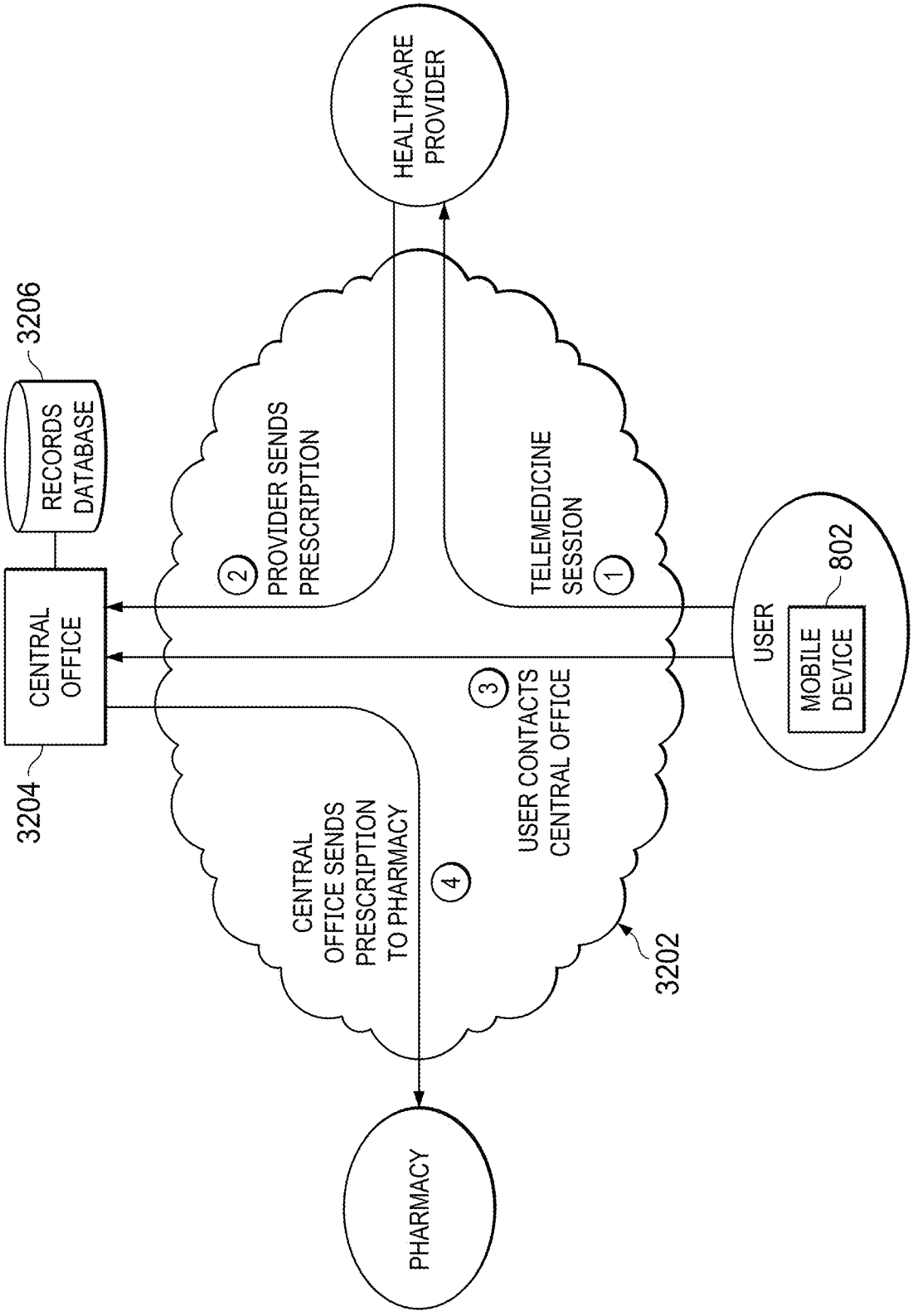

HEALTHCARE PROVIDER
3206
RECORDS DATABASE
PROVIDER SENDS PRESCRIPTION
2
TELEMEDICINE SESSION
1
CENTRAL OFFICE
USER
802
MOBILE DEVICE
3
USER CONTACTS CENTRAL OFFICE
3204
CENTRAL OFFICE SENDS PRESCRIPTION TO PHARMACY
4
3202
PHARMACY

FIG. 32B

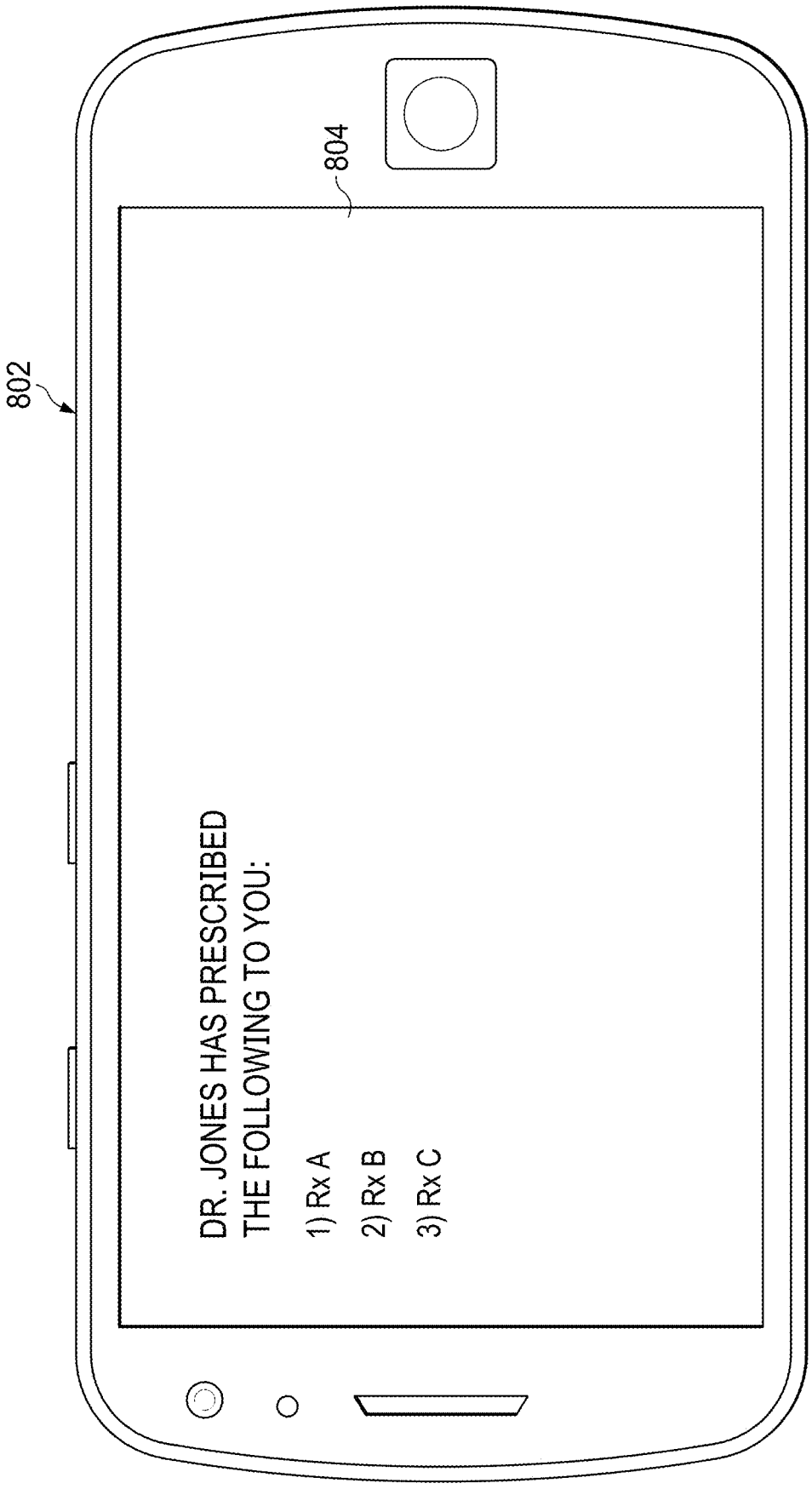

802
804
DR. JONES HAS PRESCRIBED
THE FOLLOWING TO YOU:
1) Rx A
2) Rx B
3) Rx C

FIG. 33

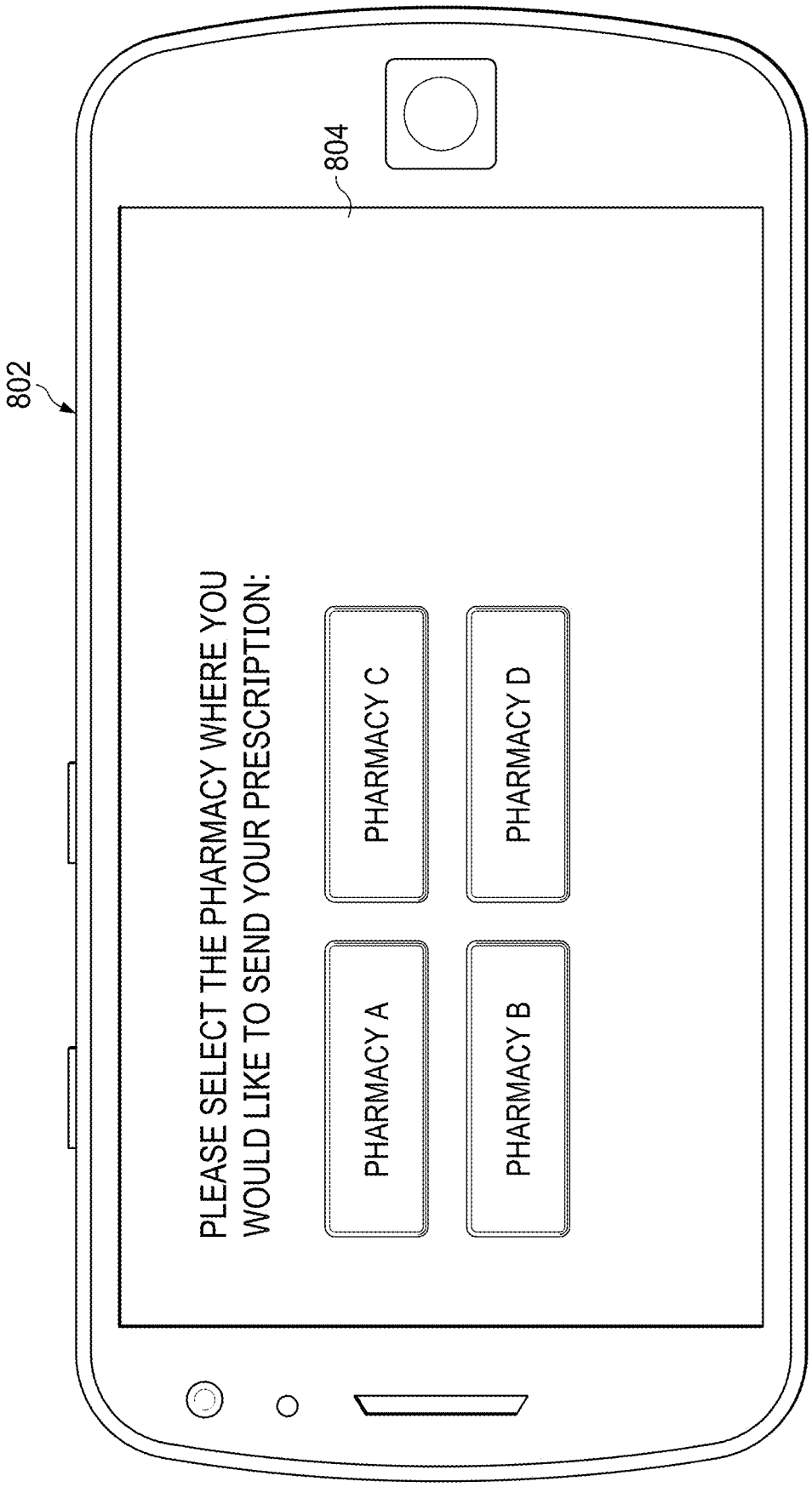

802
804
PLEASE SELECT THE PHARMACY WHERE YOU WOULD LIKE TO SEND YOUR PRESCRIPTION:
PHARMACY A
PHARMACY B
PHARMACY C
PHARMACY D

FIG. 34

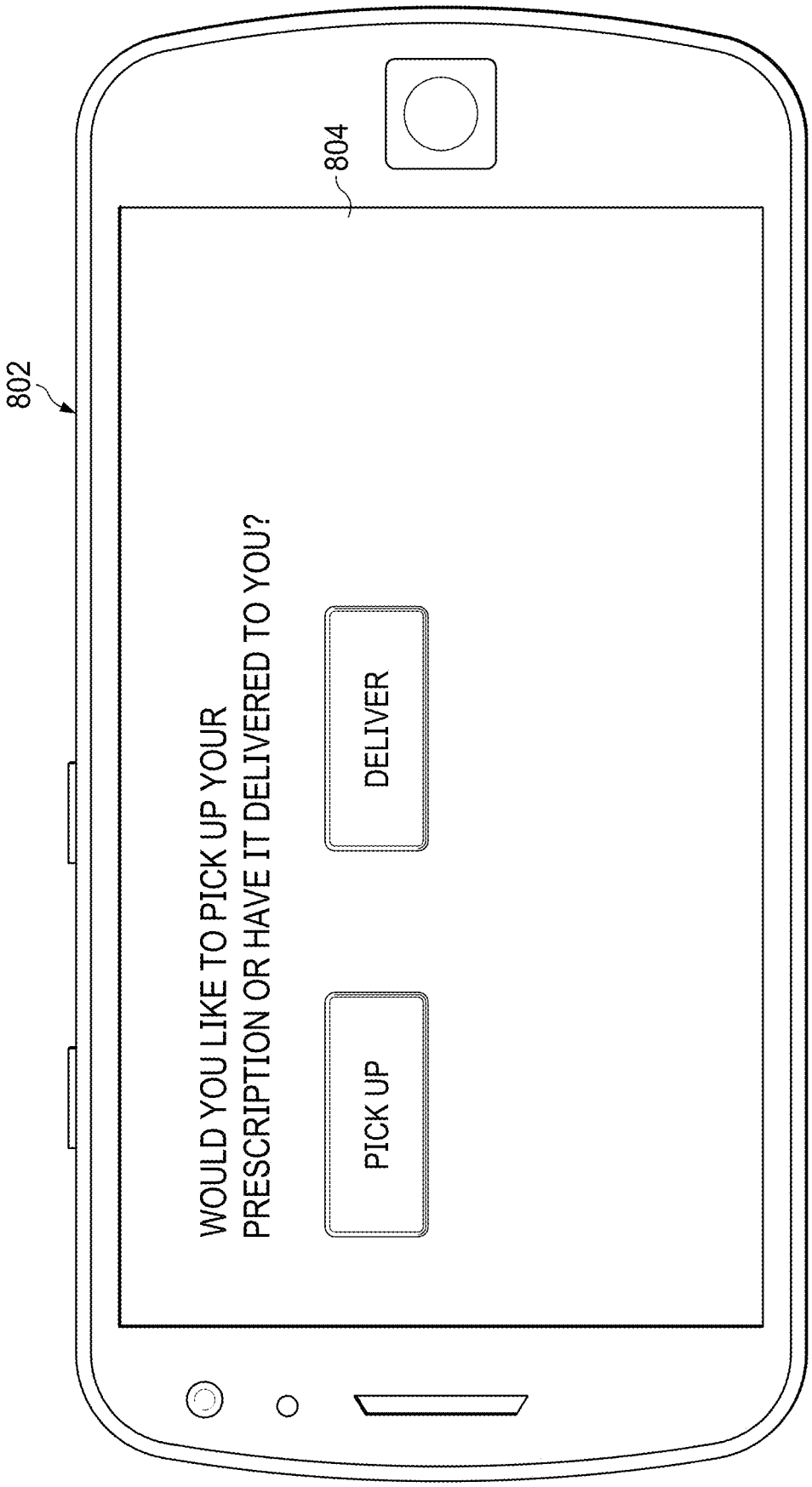

802
804
WOULD YOU LIKE TO PICK UP YOUR PRESCRIPTION OR HAVE IT DELIVERED TO YOU?
DELIVER
PICK UP

FIG. 35

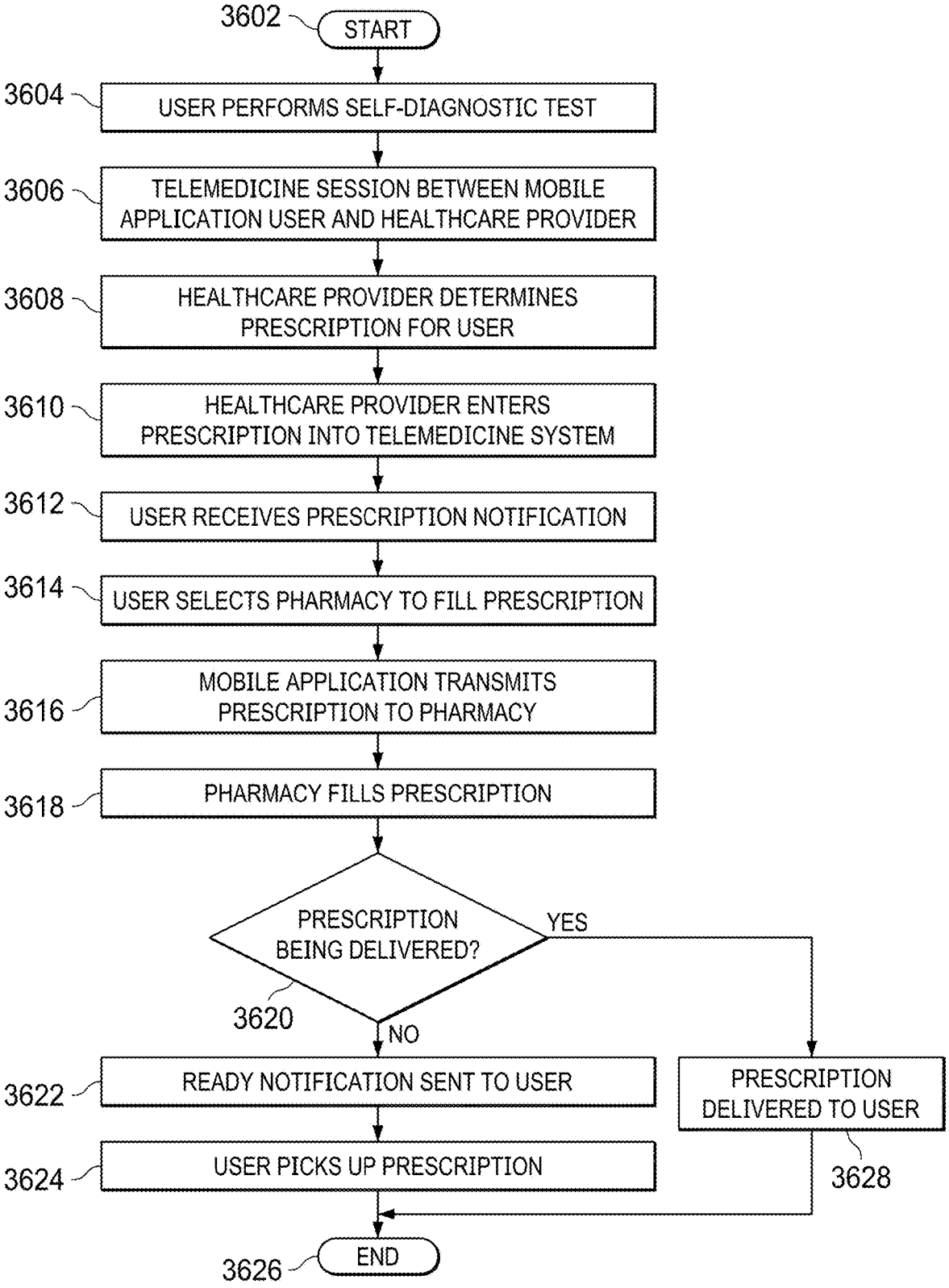

3602
START
3604
USER PERFORMS SELF-DIAGNOSTIC TEST
3606
TELEMEDICINE SESSION BETWEEN MOBILE APPLICATION USER AND HEALTHCARE PROVIDER
3608
HEALTHCARE PROVIDER DETERMINES PRESCRIPTION FOR USER
3610
HEALTHCARE PROVIDER ENTERS PRESCRIPTION INTO TELEMEDICINE SYSTEM
3612
USER RECEIVES PRESCRIPTION NOTIFICATION
3614
USER SELECTS PHARMACY TO FILL PRESCRIPTION
3616
MOBILE APPLICATION TRANSMITS PRESCRIPTION TO PHARMACY
3618
PHARMACY FILLS PRESCRIPTION
PRESCRIPTION BEING DELIVERED?
3620
YES
NO
3622
READY NOTIFICATION SENT TO USER
3624
USER PICKS UP PRESCRIPTION
PRESCRIPTION DELIVERED TO USER
3628
3626
END

FIG. 36

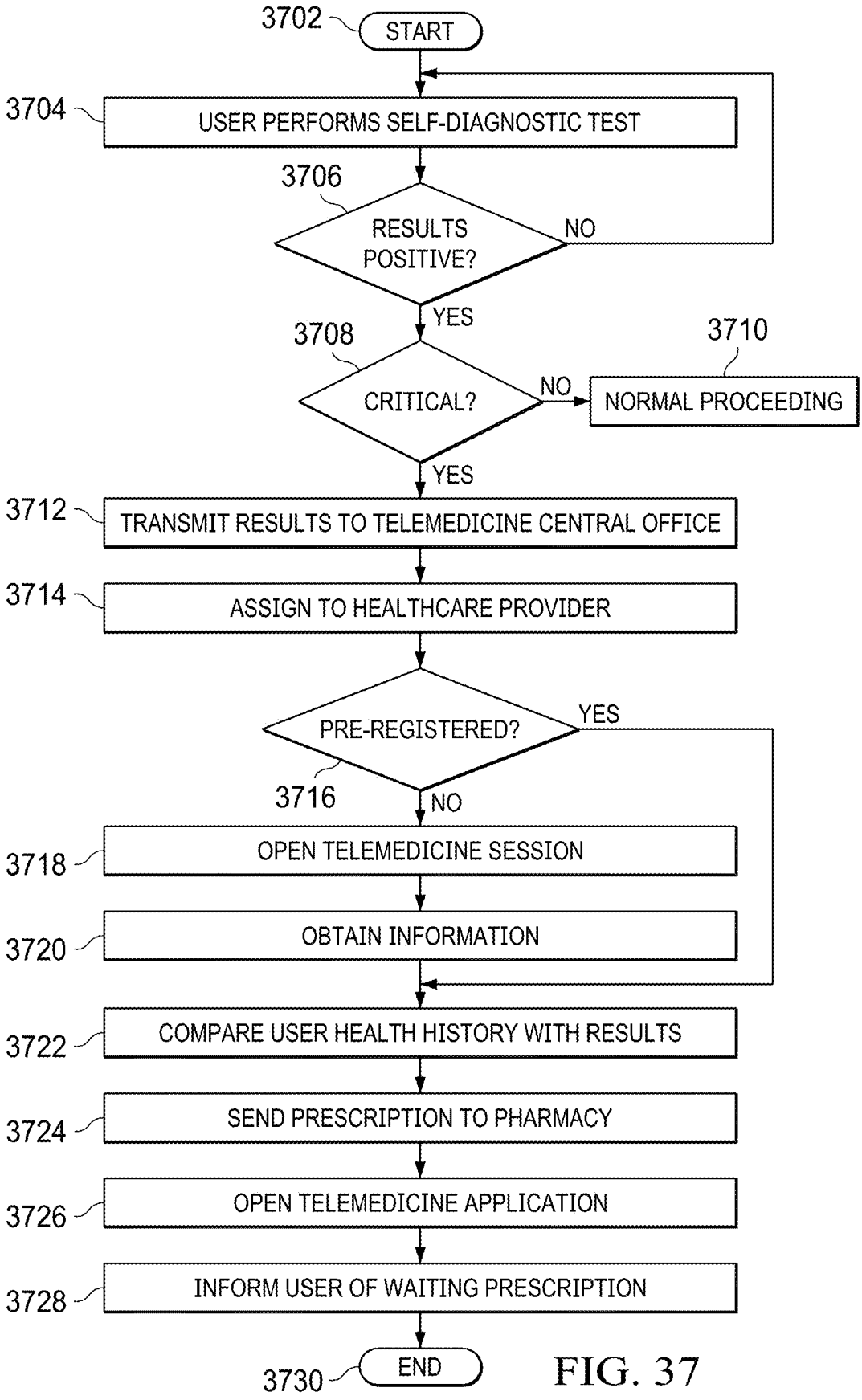

3702
START
3704
USER PERFORMS SELF-DIAGNOSTIC TEST
3706
RESULTS POSITIVE?
NO
YES
3708
CRITICAL?
NO
3710
NORMAL PROCEEDING
YES
3712
TRANSMIT RESULTS TO TELEMEDICINE CENTRAL OFFICE
3714
ASSIGN TO HEALTHCARE PROVIDER
PRE-REGISTERED?
YES
3716
NO
3718
OPEN TELEMEDICINE SESSION
3720
OBTAIN INFORMATION
3722
COMPARE USER HEALTH HISTORY WITH RESULTS
3724
SEND PRESCRIPTION TO PHARMACY
3726
OPEN TELEMEDICINE APPLICATION
3728
INFORM USER OF WAITING PRESCRIPTION
3730
END

FIG. 37

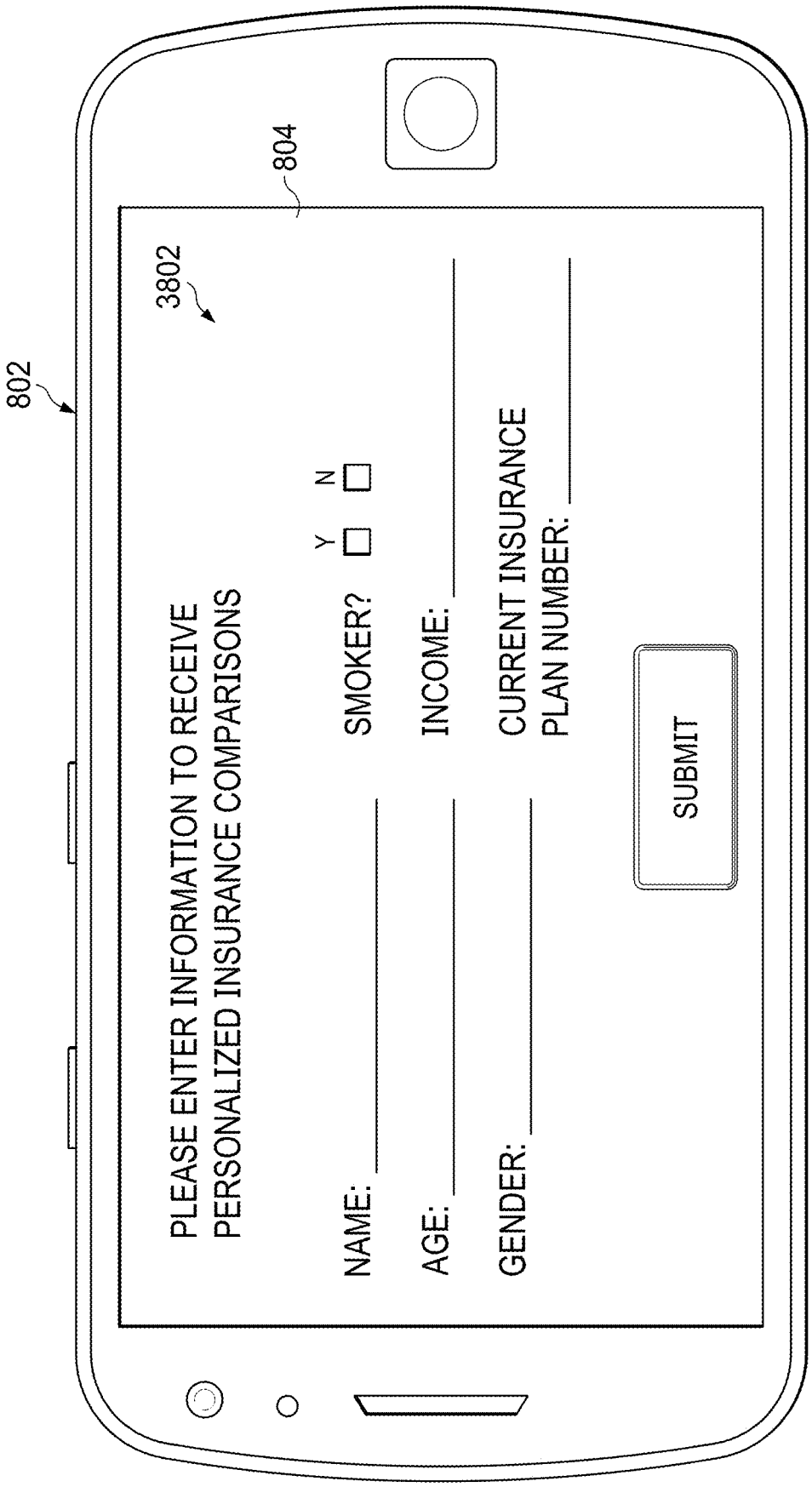

802
804
3802
PLEASE ENTER INFORMATION TO RECEIVE
PERSONALIZED INSURANCE COMPARISONS
NAME: _____
SMOKER? Y ☐ N ☐
AGE: _____
INCOME: _____
GENDER: _____
CURRENT INSURANCE
PLAN NUMBER: _____
SUBMIT

FIG. 38

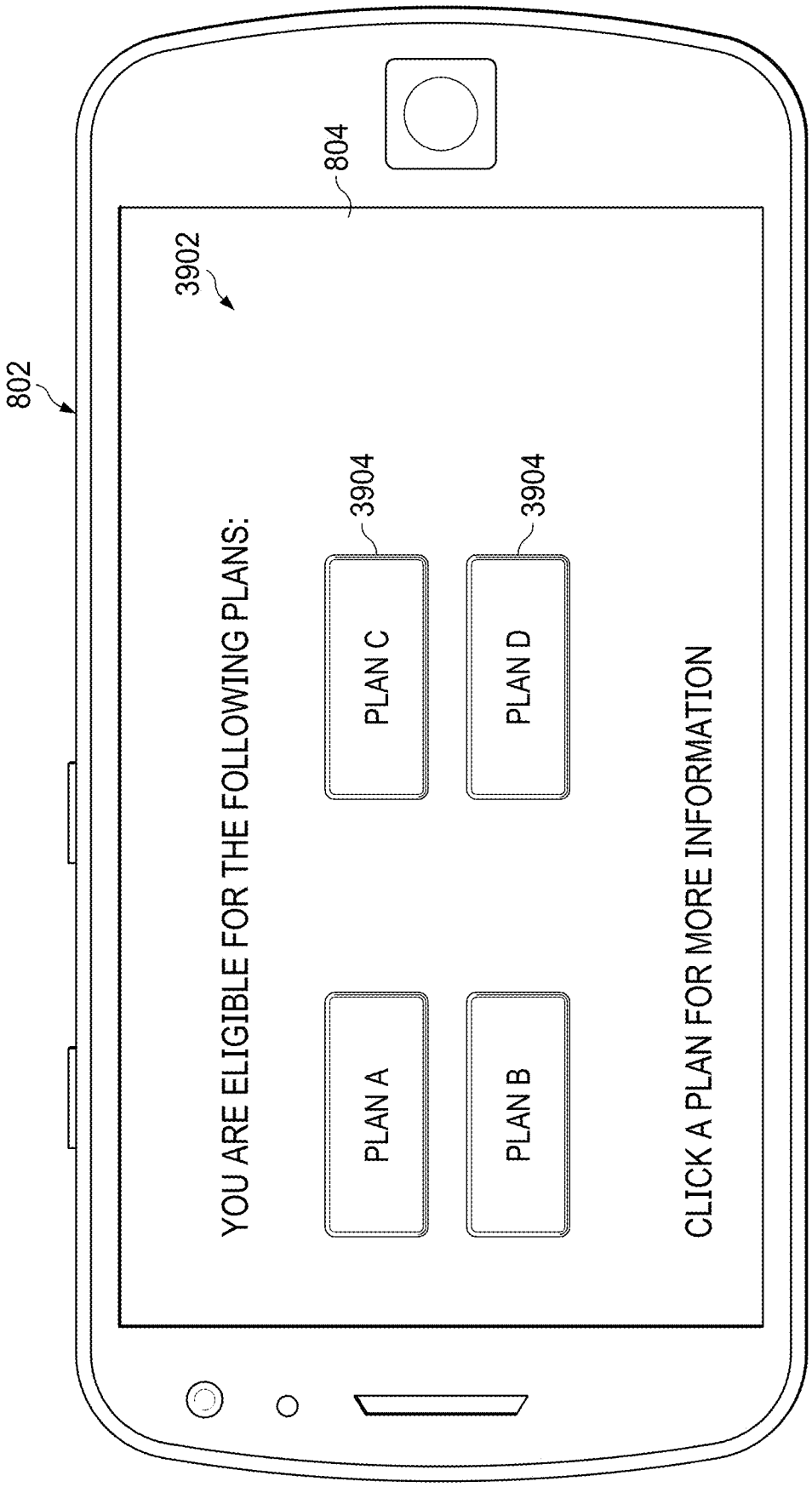

802
804
3902
YOU ARE ELIGIBLE FOR THE FOLLOWING PLANS:
3904
PLAN C
3904
PLAN D
PLAN A
PLAN B
CLICK A PLAN FOR MORE INFORMATION

FIG. 39

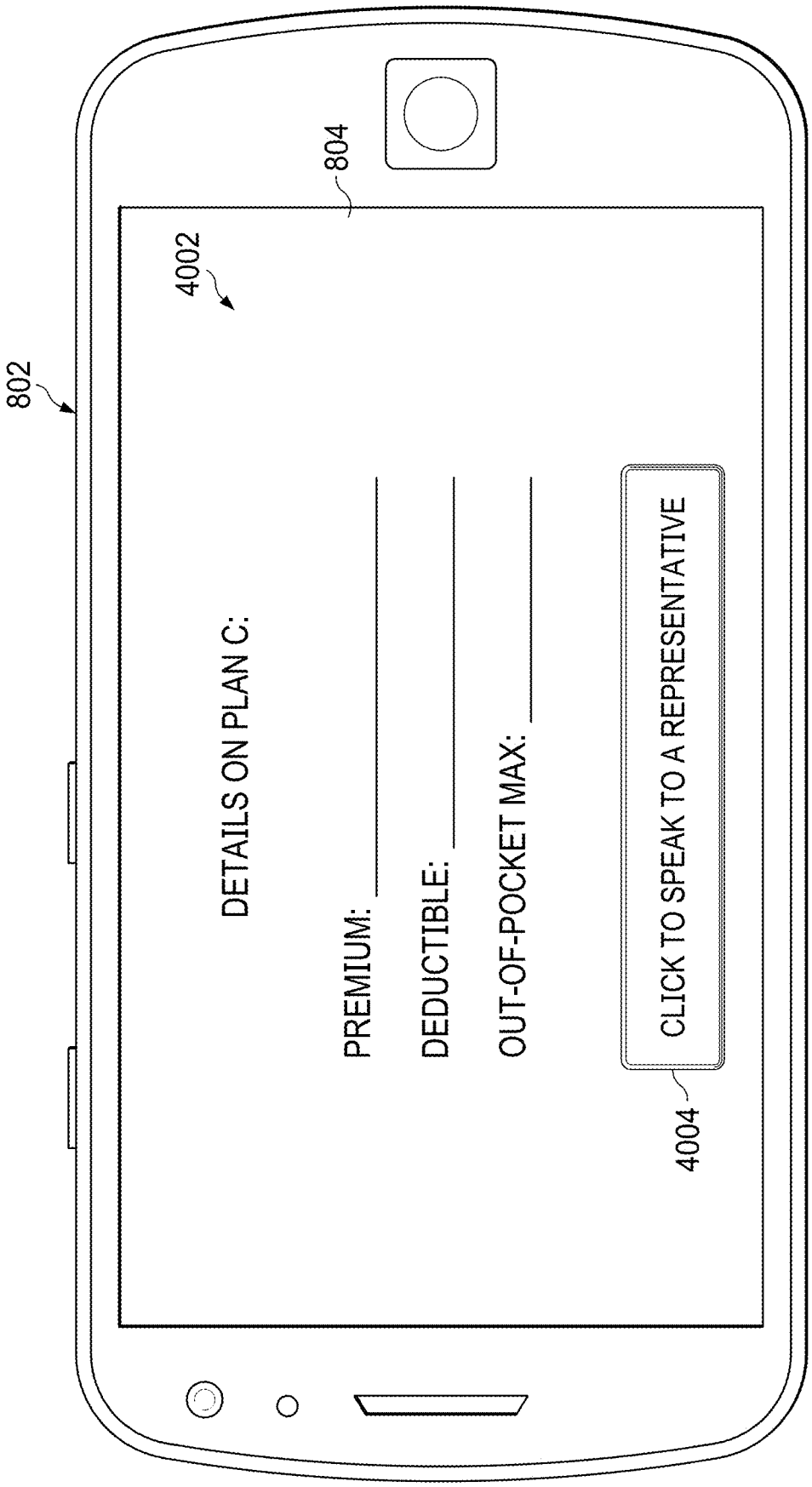

802
804
4002
DETAILS ON PLAN C:
PREMIUM: _____
DEDUCTIBLE: _____
OUT-OF-POCKET MAX: _____
CLICK TO SPEAK TO A REPRESENTATIVE
4004

FIG. 40

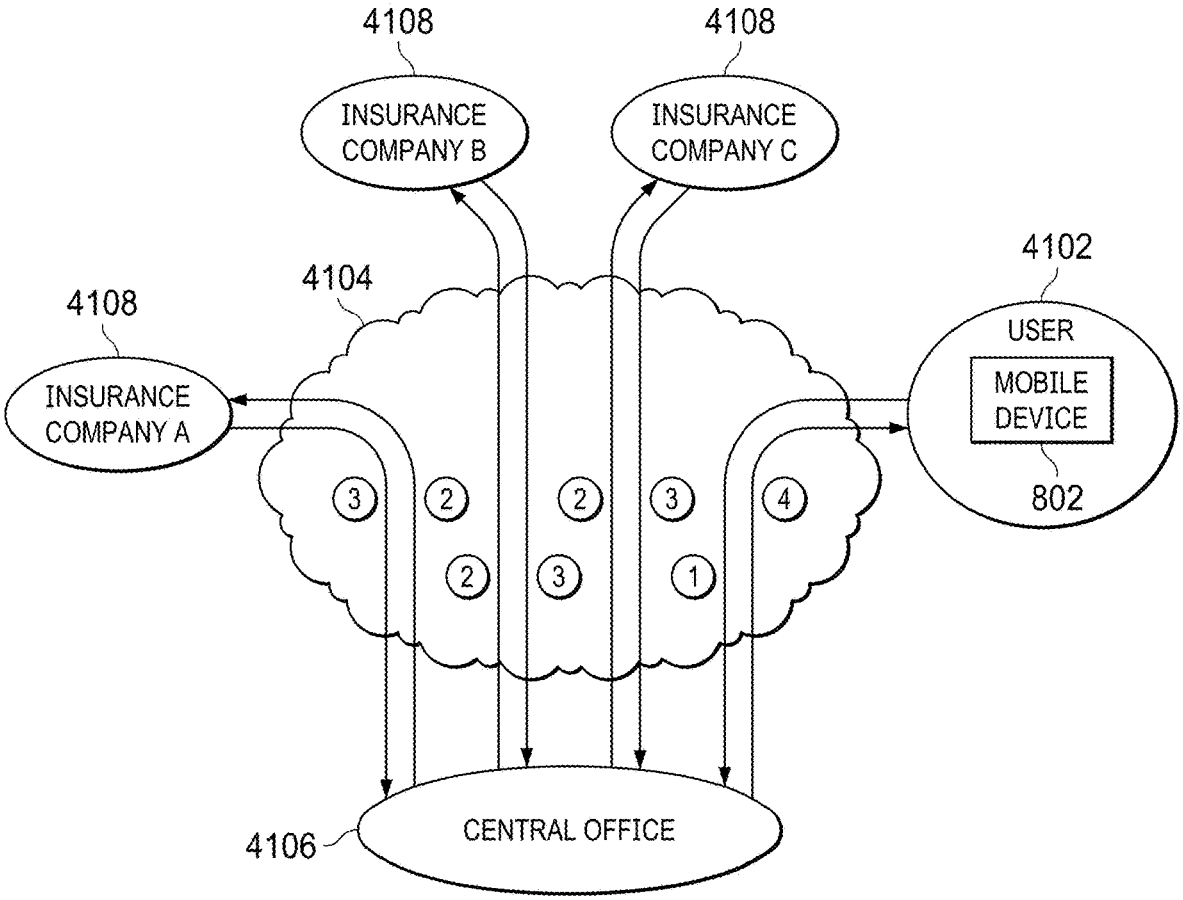

4108
INSURANCE COMPANY B
4108
INSURANCE COMPANY C
4102
USER
MOBILE DEVICE
802
4104
4108
INSURANCE COMPANY A
3
2
2
3
4
2
3
1
4106
CENTRAL OFFICE

FIG. 41

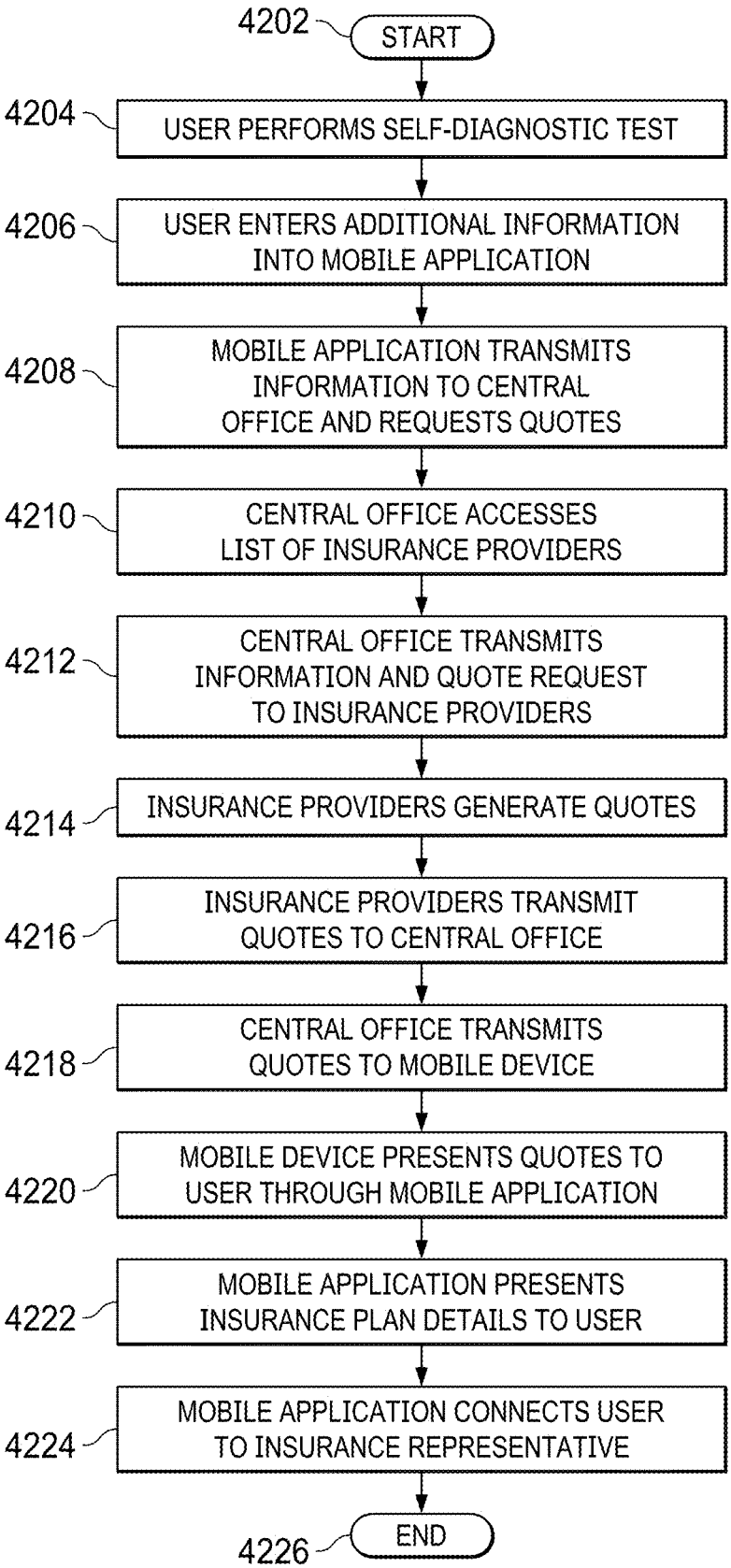

4202
START
4204
USER PERFORMS SELF-DIAGNOSTIC TEST
4206
USER ENTERS ADDITIONAL INFORMATION INTO MOBILE APPLICATION
4208
MOBILE APPLICATION TRANSMITS INFORMATION TO CENTRAL OFFICE AND REQUESTS QUOTES
4210
CENTRAL OFFICE ACCESSES LIST OF INSURANCE PROVIDERS
4212
CENTRAL OFFICE TRANSMITS INFORMATION AND QUOTE REQUEST TO INSURANCE PROVIDERS
4214
INSURANCE PROVIDERS GENERATE QUOTES
4216
INSURANCE PROVIDERS TRANSMIT QUOTES TO CENTRAL OFFICE
4218
CENTRAL OFFICE TRANSMITS QUOTES TO MOBILE DEVICE
4220
MOBILE DEVICE PRESENTS QUOTES TO USER THROUGH MOBILE APPLICATION
4222
MOBILE APPLICATION PRESENTS INSURANCE PLAN DETAILS TO USER
4224
MOBILE APPLICATION CONNECTS USER TO INSURANCE REPRESENTATIVE
4226
END

FIG. 42

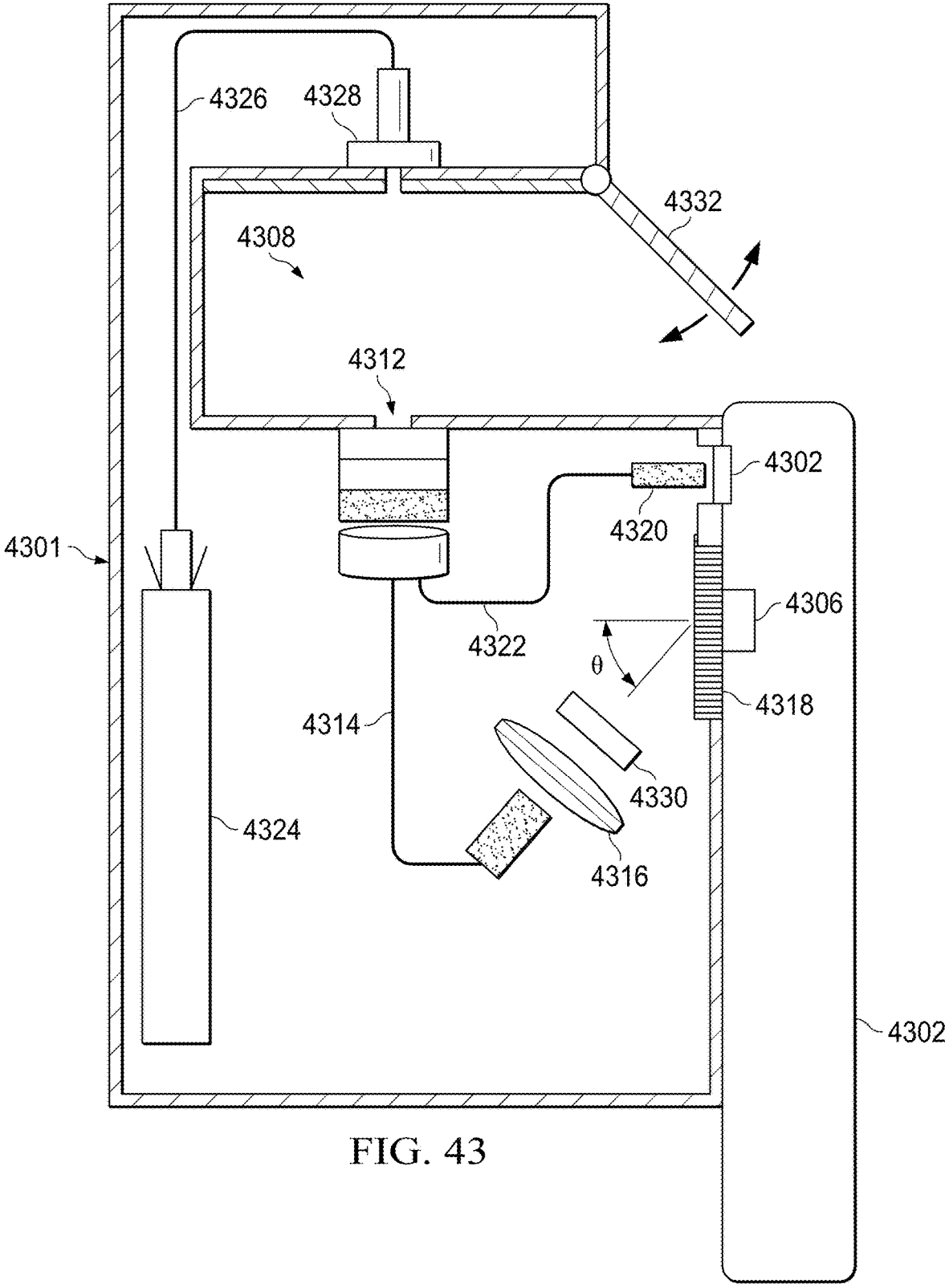

4326
4328
4332
4308
4312
4302
4320
4301
4306
4322
θ
4318
4314
4330
4324
4316
4302

FIG. 43

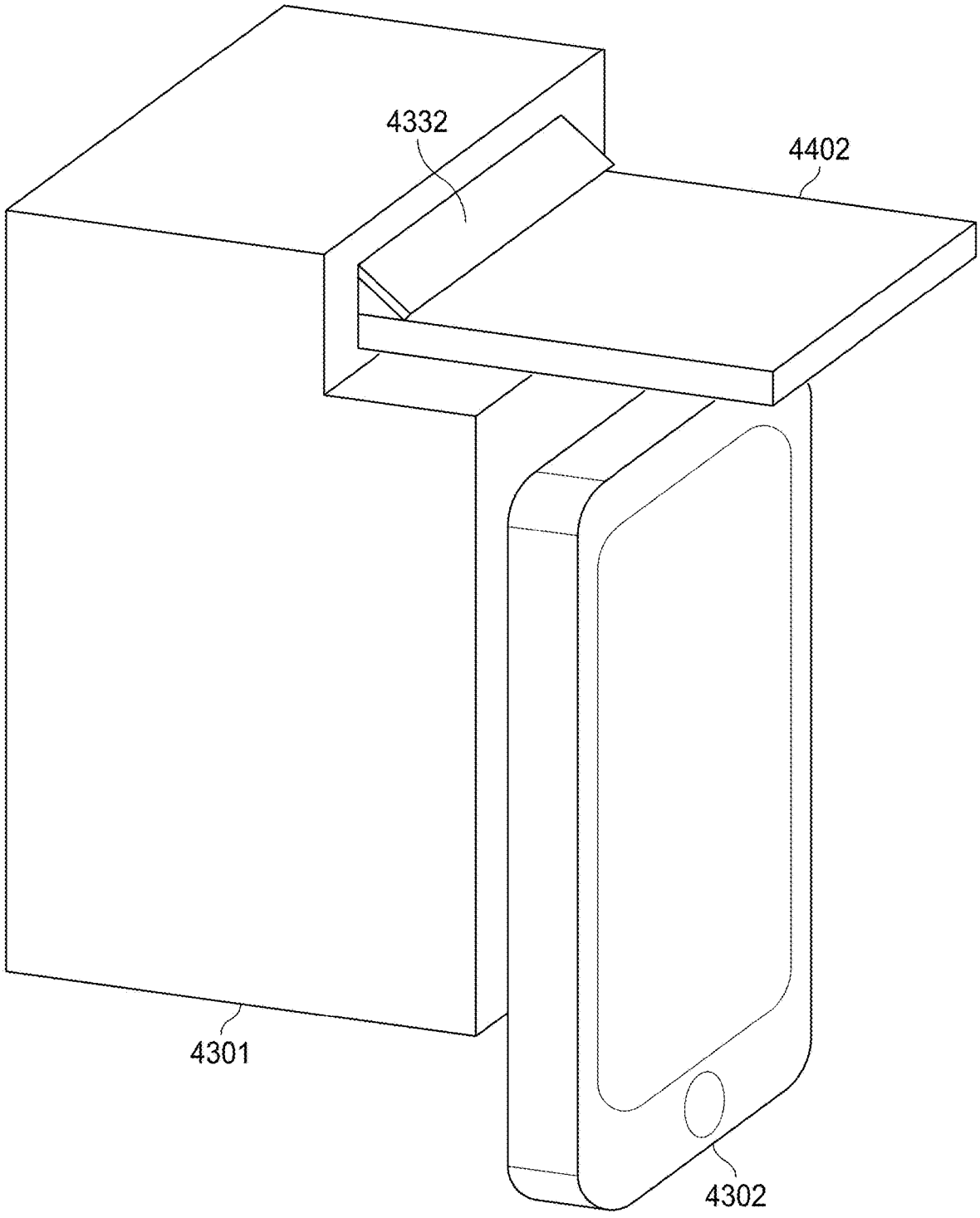


FIG. 44

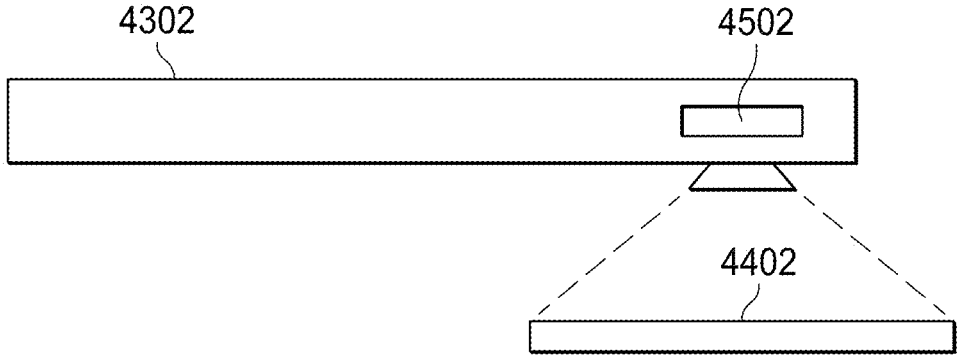


FIG. 45

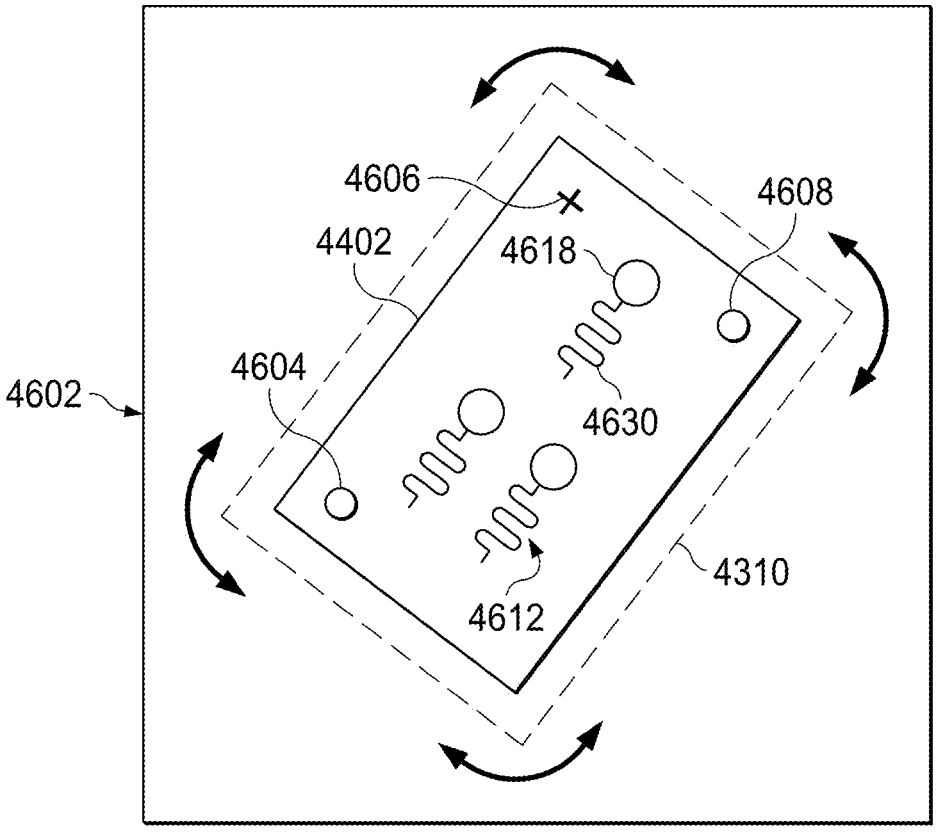


FIG. 46

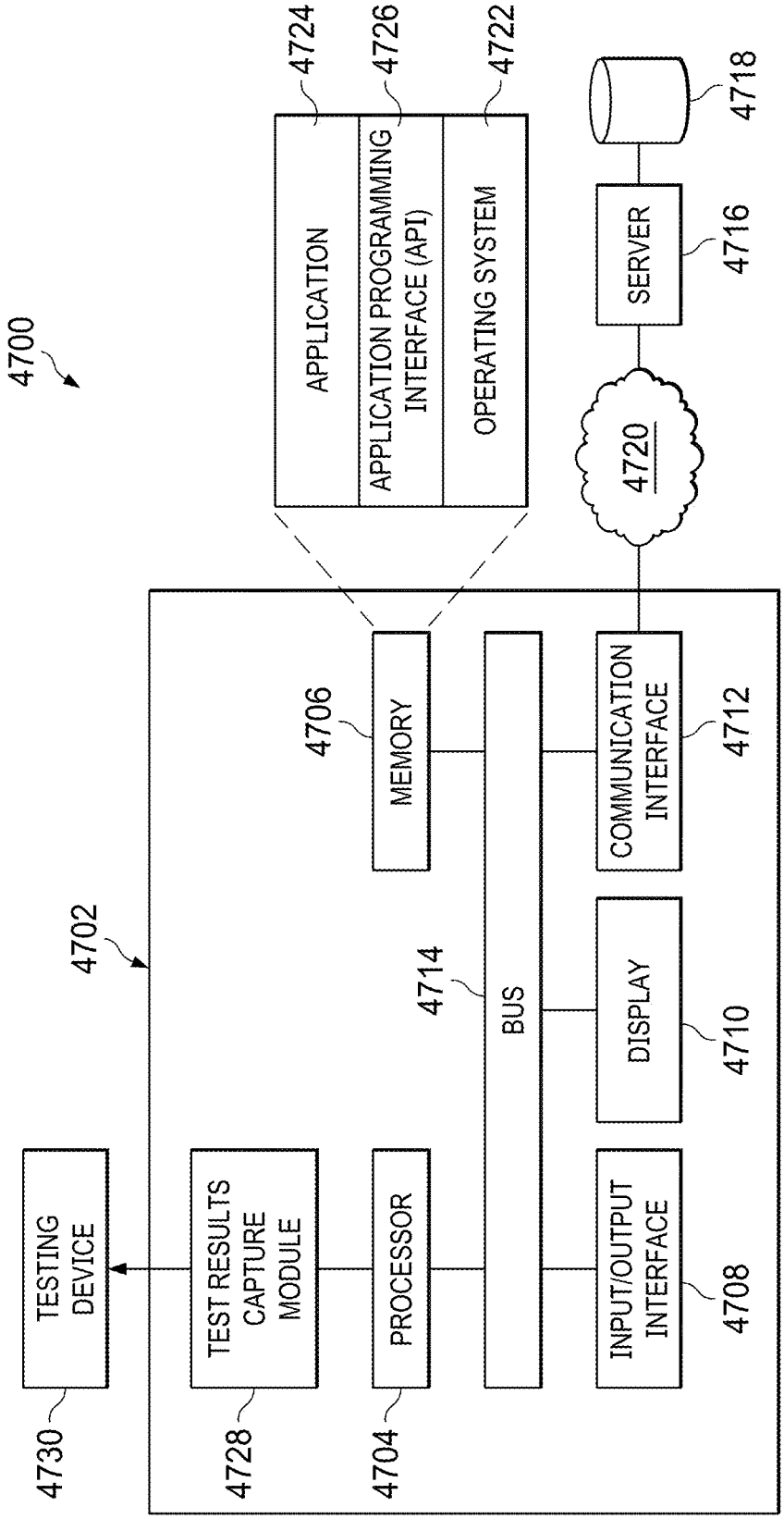

4700
4724
4726
4722
APPLICATION
APPLICATION PROGRAMMING INTERFACE (API)
OPERATING SYSTEM
4718
SERVER
4716
4720
4706
MEMORY
BUS
COMMUNICATION INTERFACE
4712
4702
4714
DISPLAY
4710
TESTING DEVICE
TEST RESULTS CAPTURE MODULE
PROCESSOR
INPUT/OUTPUT INTERFACE
4708
4730
4728
4704

FIG. 47

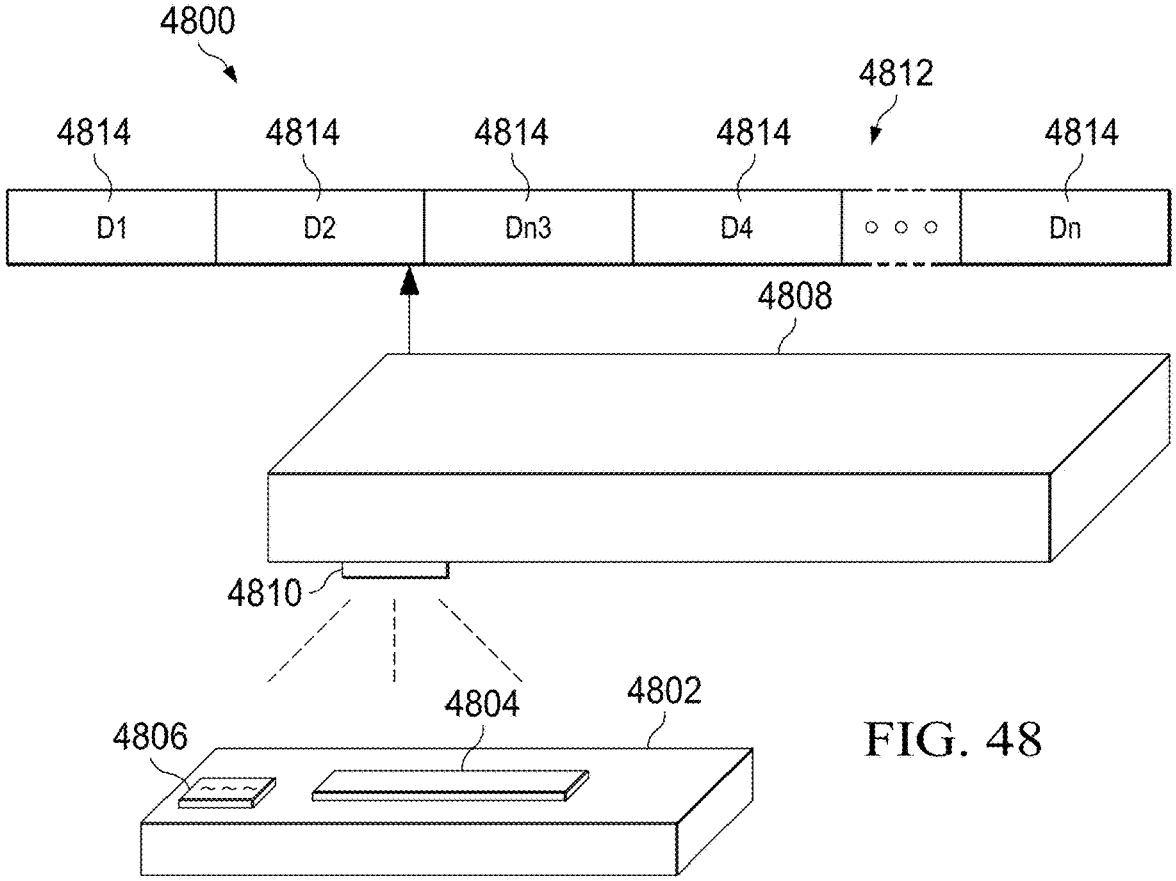

4800
4812
4814
4814
4814
4814
4814
D1
D2
Dn3
D4
Dn
4808
4810
4804
4802
4806

FIG. 48

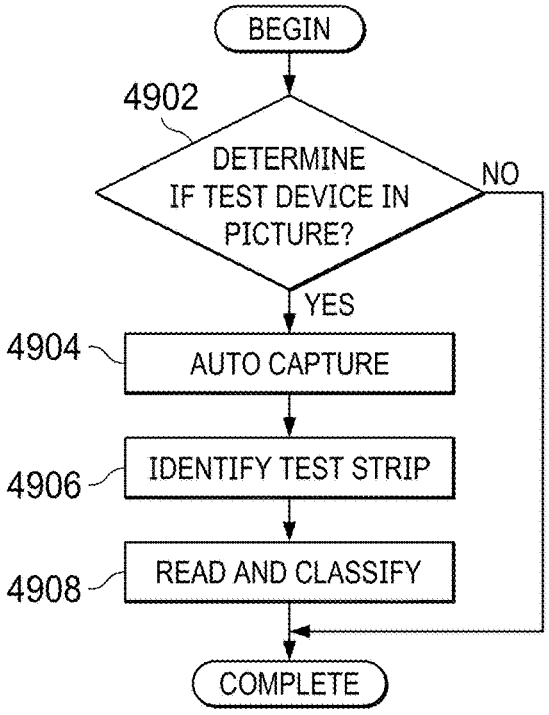
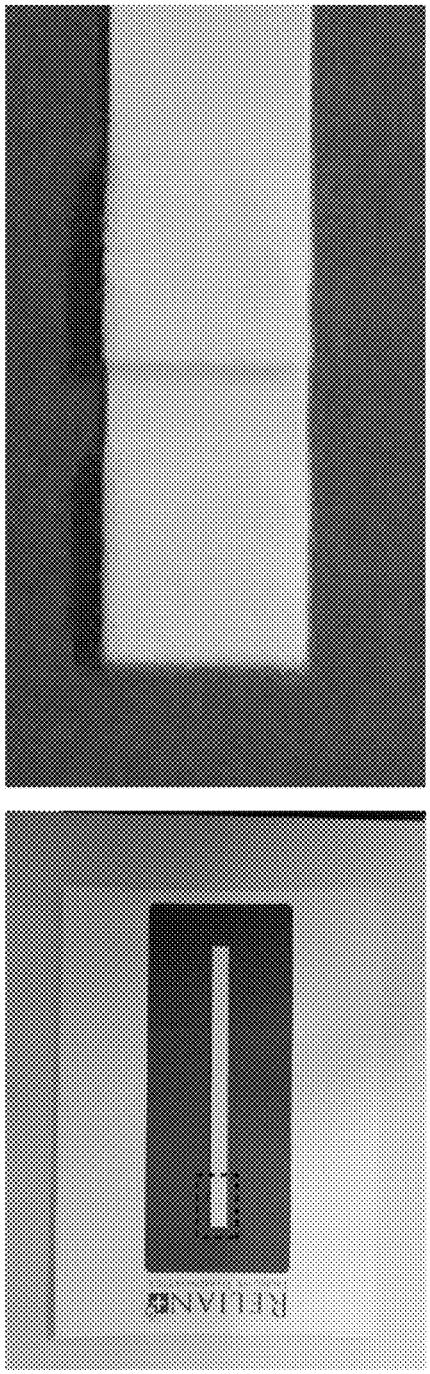

BEGIN
4902
DETERMINE IF TEST DEVICE IN PICTURE?
NO
YES
4904
AUTO CAPTURE
4906
IDENTIFY TEST STRIP
4908
READ AND CLASSIFY
COMPLETE

FIG. 49



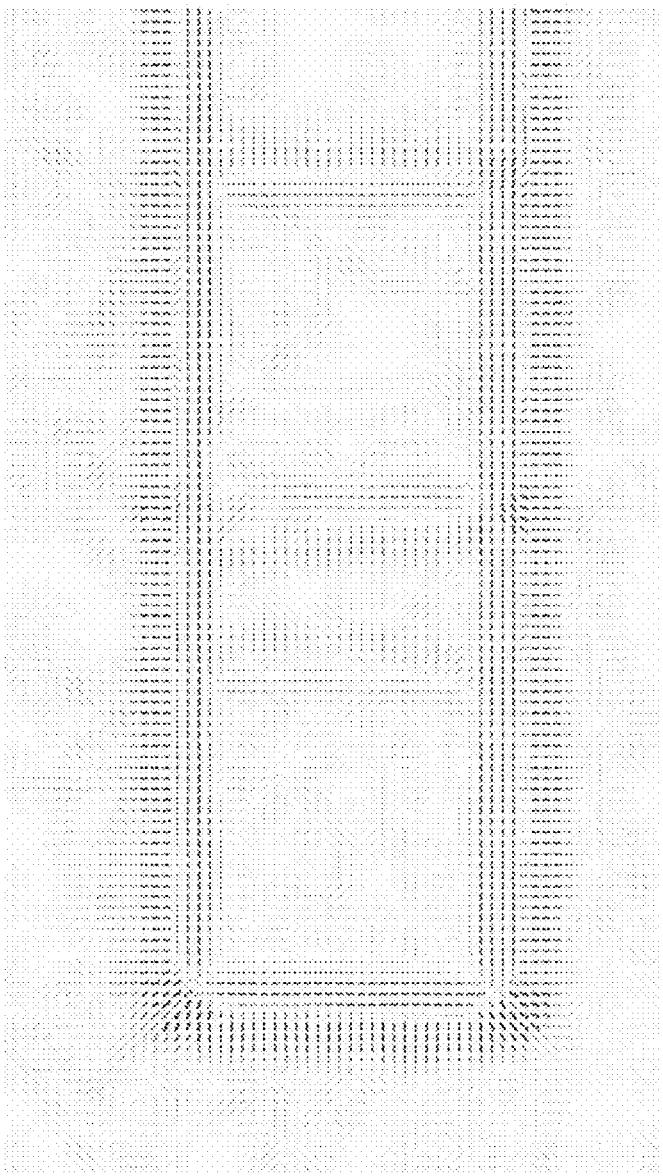


FIG. 50

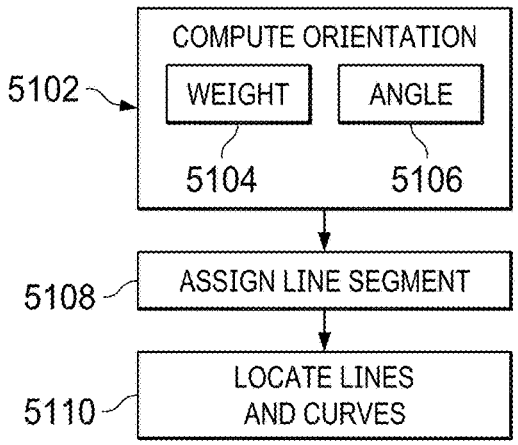

COMPUTE ORIENTATION
WEIGHT
ANGLE
5102
5104
5106
ASSIGN LINE SEGMENT
5108
LOCATE LINES AND CURVES
5110

FIG. 51

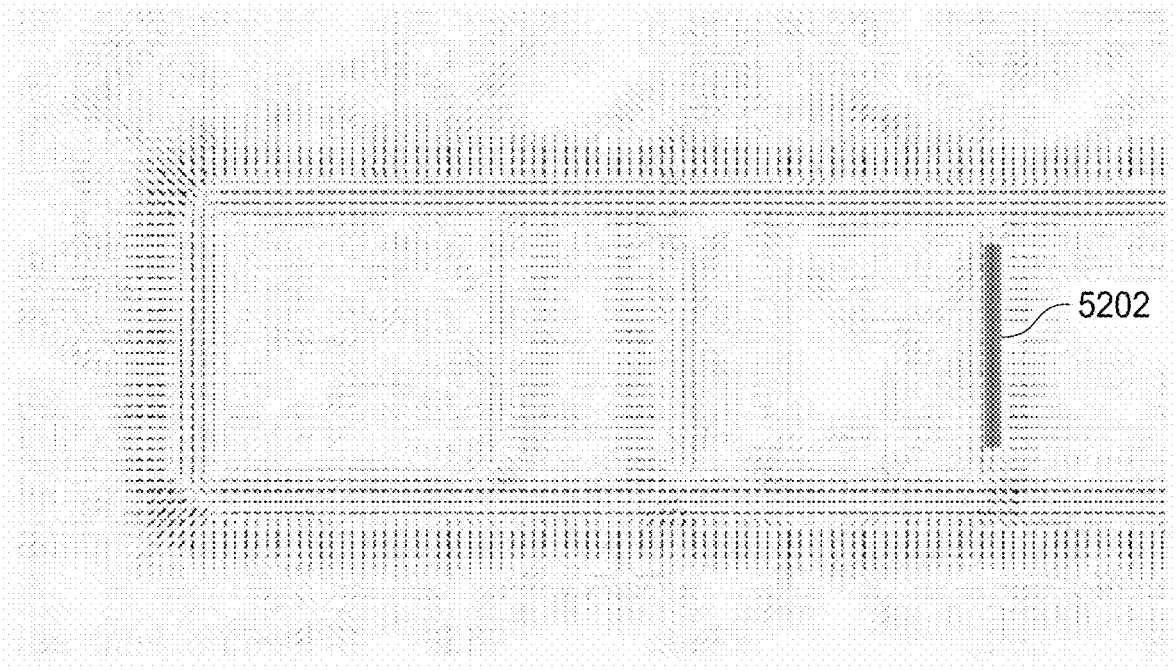

5202

FIG. 52

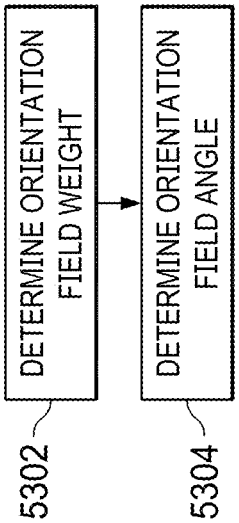

DETERMINE ORIENTATION FIELD WEIGHT
DETERMINE ORIENTATION FIELD ANGLE
5302
5304

FIG. 53

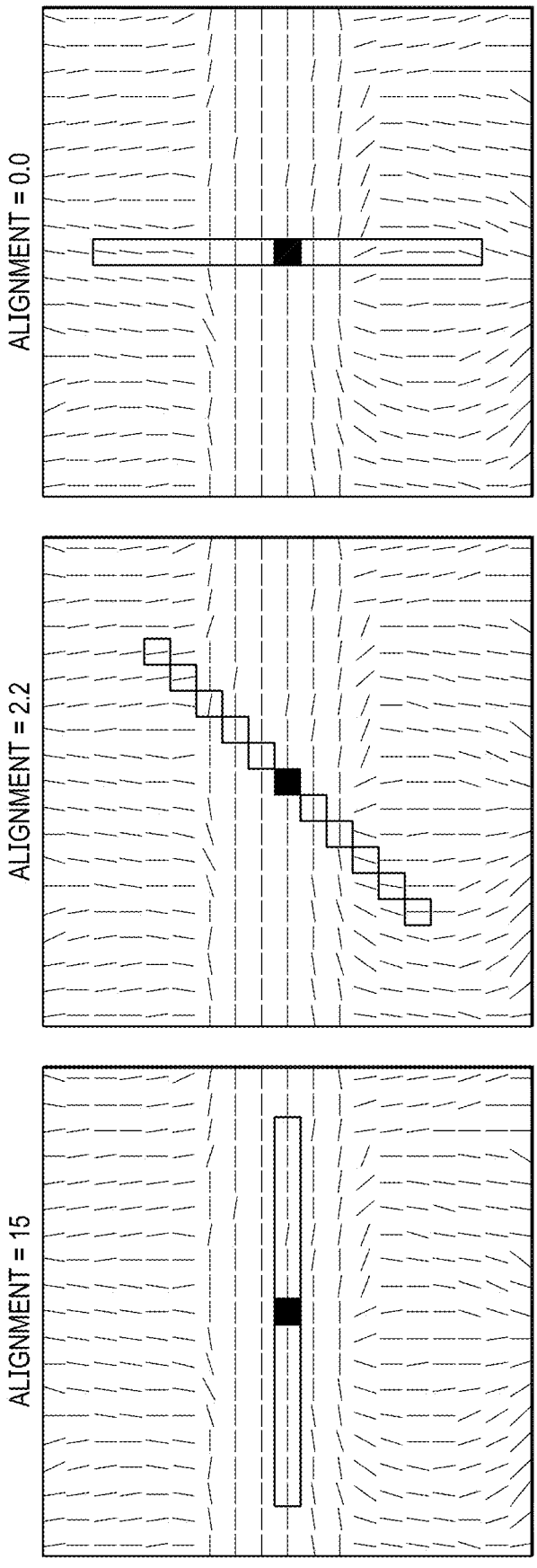

ALIGNMENT = 0.0
ALIGNMENT = 2.2
ALIGNMENT = 15

FIG. 54

FIG. 55

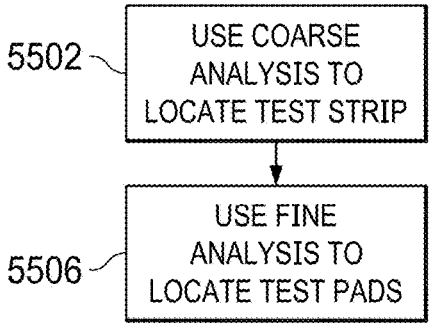


FIG. 56

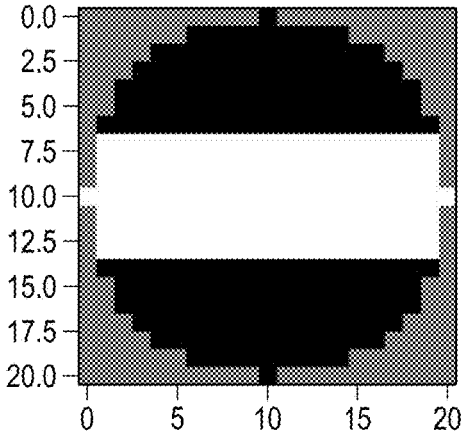
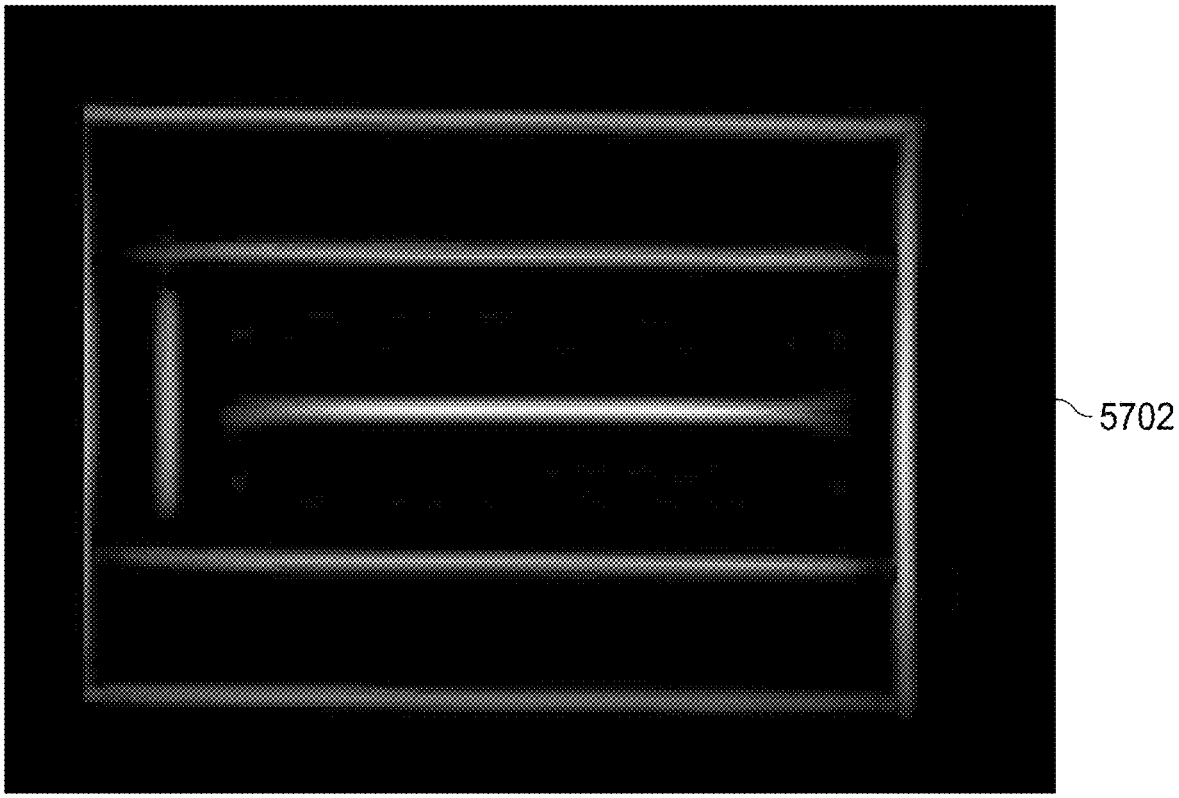


FIG. 57



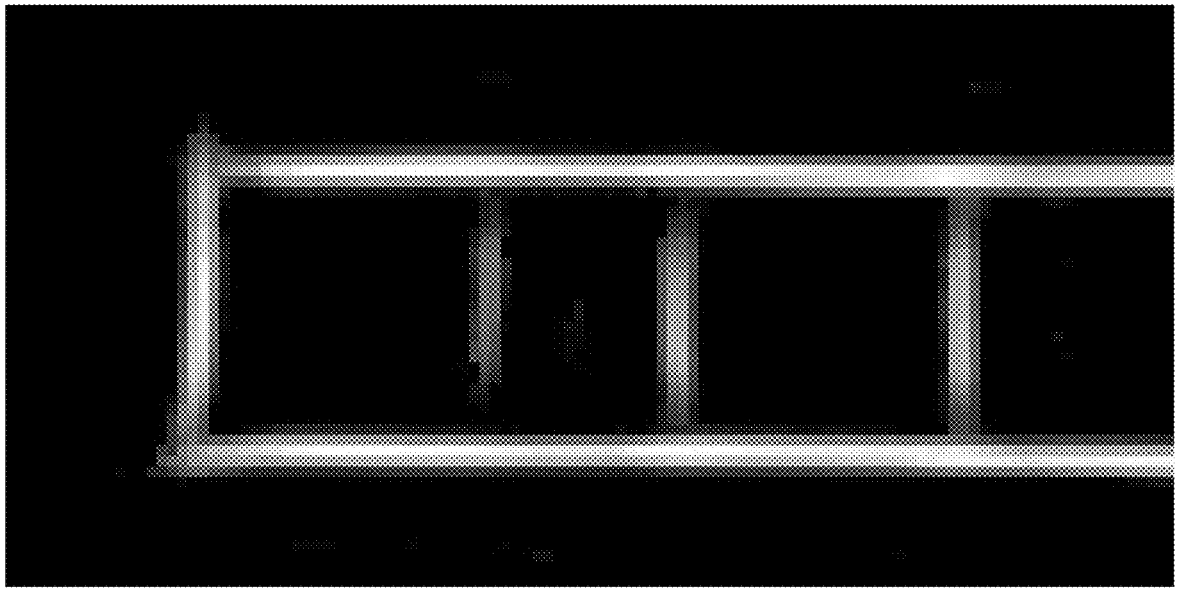


FIG. 58

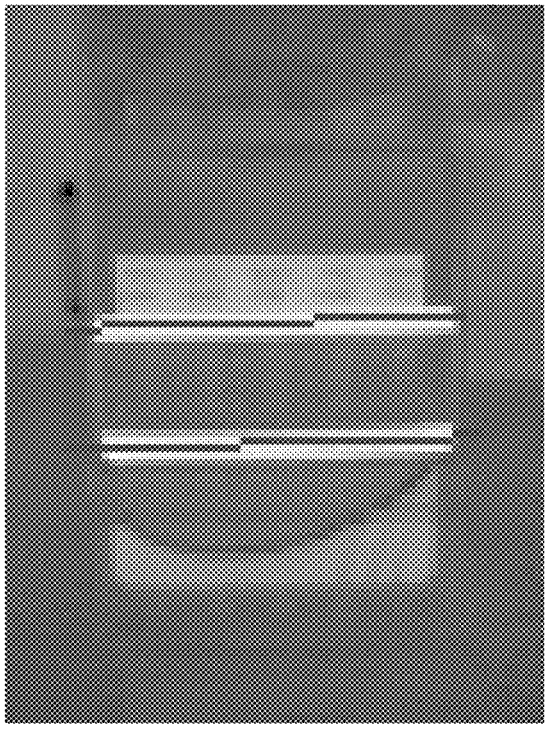


FIG. 59

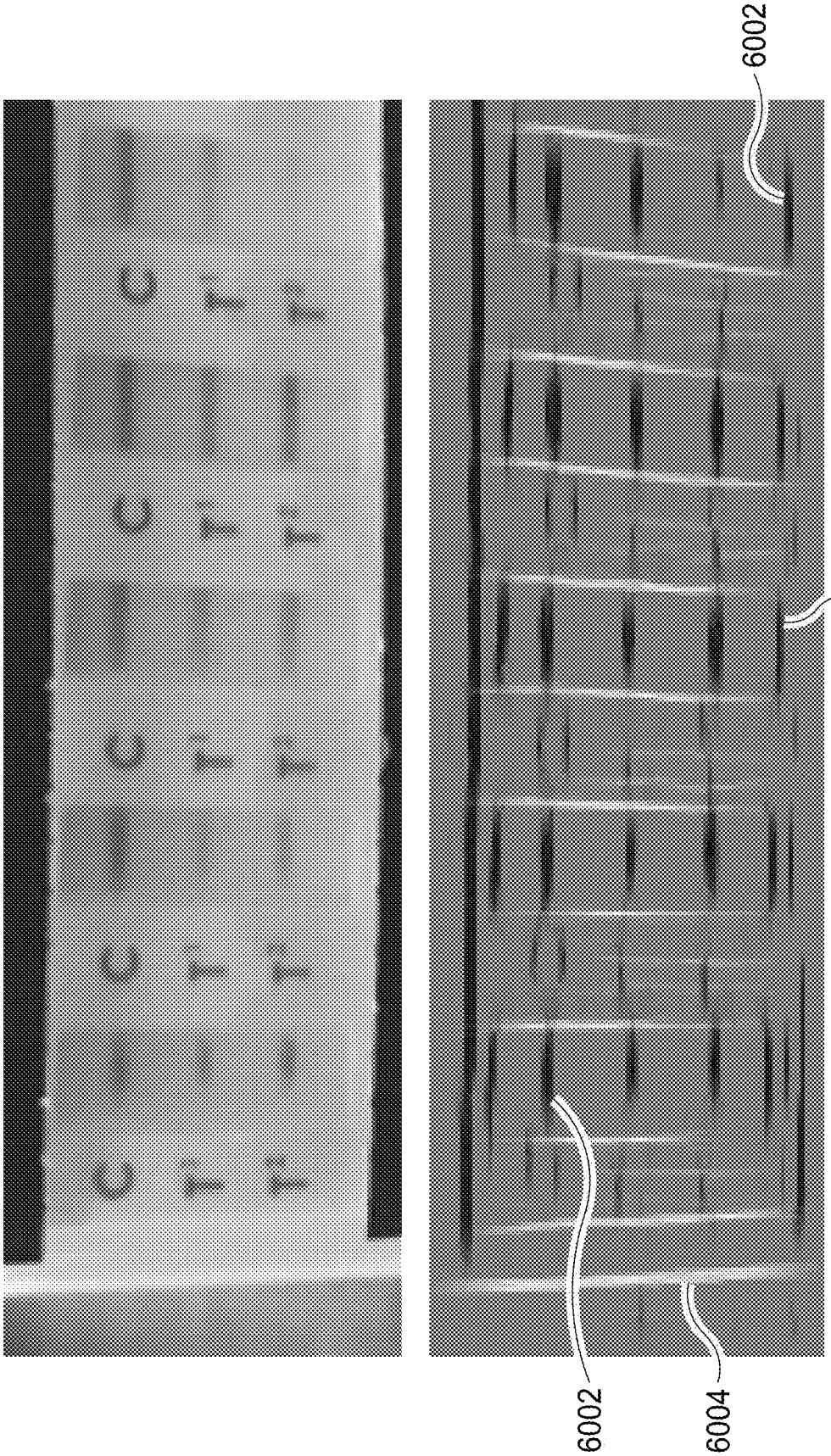


FIG. 60

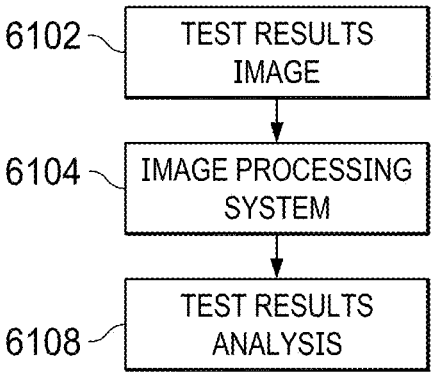

6102
TEST RESULTS IMAGE
6104
IMAGE PROCESSING SYSTEM
6108
TEST RESULTS ANALYSIS

FIG. 61

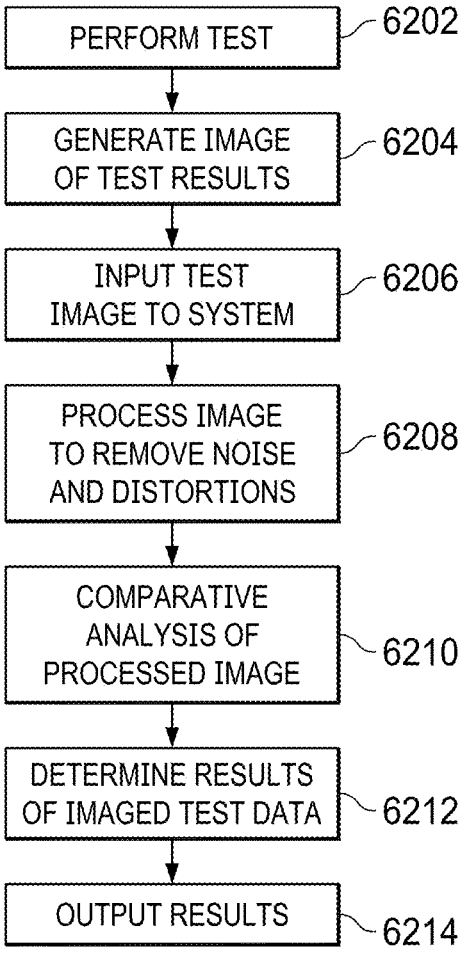

PERFORM TEST
6202
GENERATE IMAGE OF TEST RESULTS
6204
INPUT TEST IMAGE TO SYSTEM
6206
PROCESS IMAGE TO REMOVE NOISE AND DISTORTIONS
6208
COMPARATIVE ANALYSIS OF PROCESSED IMAGE
6210
DETERMINE RESULTS OF IMAGED TEST DATA
6212
OUTPUT RESULTS
6214

FIG. 62

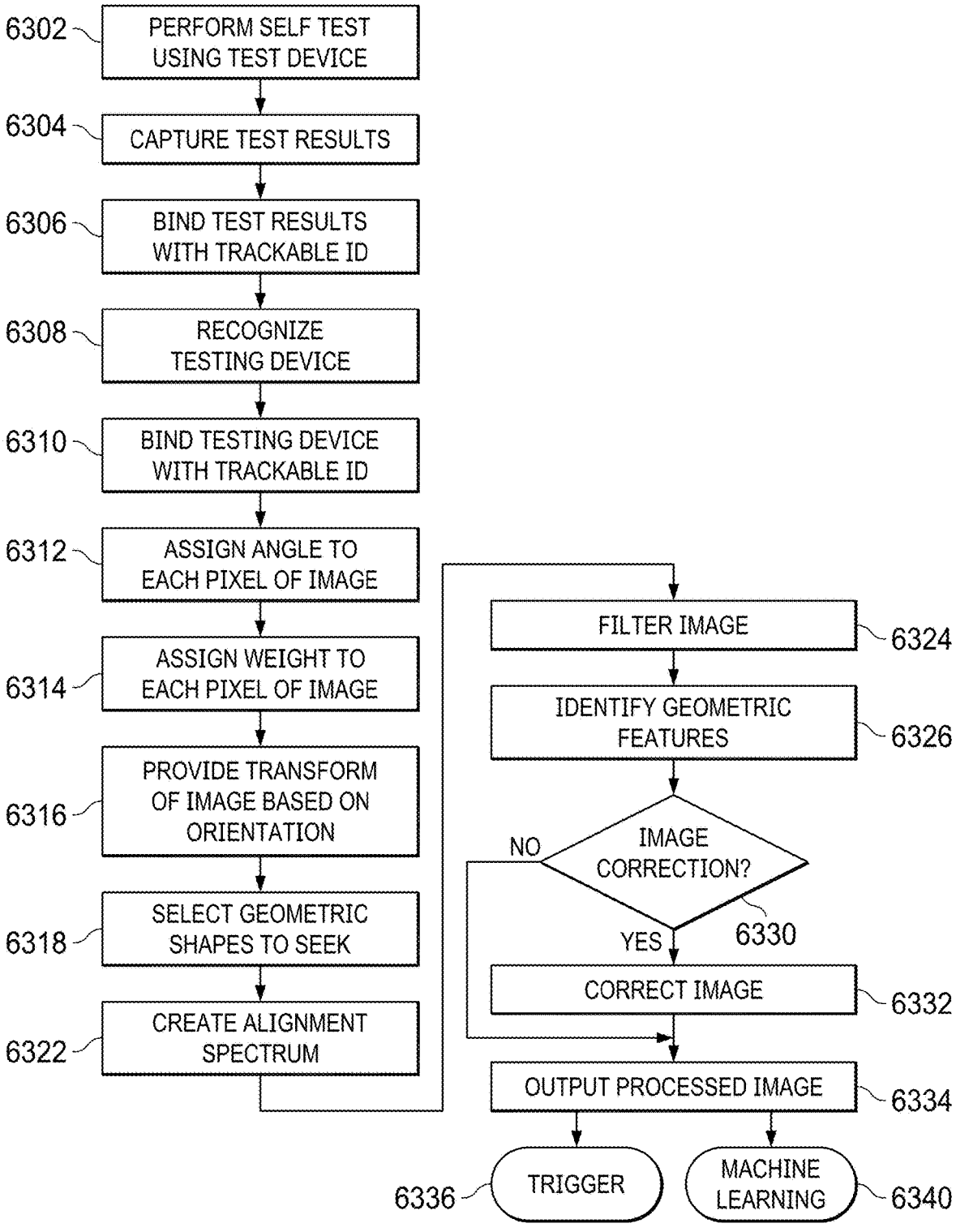

6302
PERFORM SELF TEST USING TEST DEVICE
6304
CAPTURE TEST RESULTS
6306
BIND TEST RESULTS WITH TRACKABLE ID
6308
RECOGNIZE TESTING DEVICE
6310
BIND TESTING DEVICE WITH TRACKABLE ID
6312
ASSIGN ANGLE TO EACH PIXEL OF IMAGE
6314
ASSIGN WEIGHT TO EACH PIXEL OF IMAGE
6316
PROVIDE TRANSFORM OF IMAGE BASED ON ORIENTATION
6318
SELECT GEOMETRIC SHAPES TO SEEK
6322
CREATE ALIGNMENT SPECTRUM
FILTER IMAGE
6324
IDENTIFY GEOMETRIC FEATURES
6326
IMAGE CORRECTION?
6330
NO
YES
CORRECT IMAGE
6332
OUTPUT PROCESSED IMAGE
6334
6336
TRIGGER
MACHINE LEARNING
6340

FIG. 63

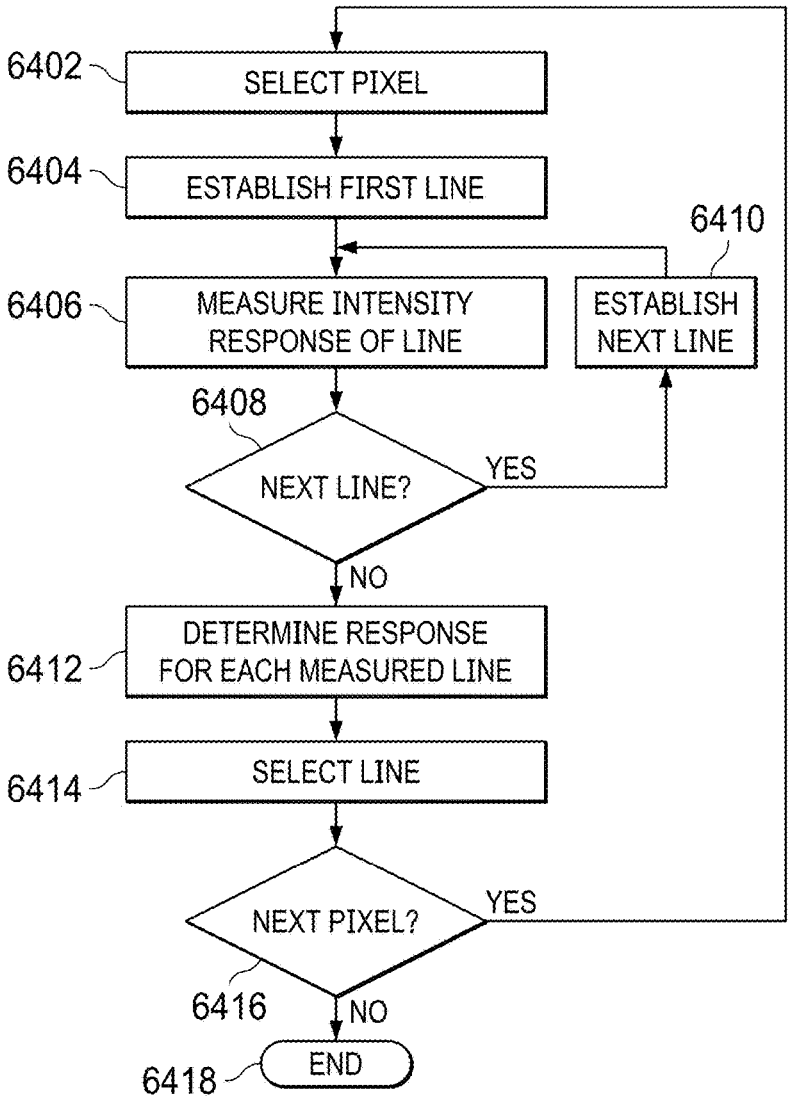

6402
SELECT PIXEL
6404
ESTABLISH FIRST LINE
6410
6406
MEASURE INTENSITY RESPONSE OF LINE
ESTABLISH NEXT LINE
6408
NEXT LINE?
YES
NO
6412
DETERMINE RESPONSE FOR EACH MEASURED LINE
6414
SELECT LINE
NEXT PIXEL?
YES
6416
NO
6418
END

FIG. 64

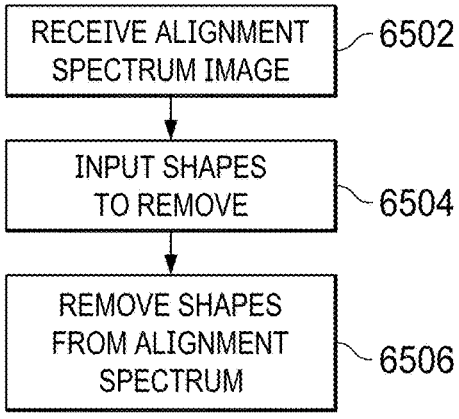

RECEIVE ALIGNMENT SPECTRUM IMAGE
6502
INPUT SHAPES TO REMOVE
6504
REMOVE SHAPES FROM ALIGNMENT SPECTRUM
6506

FIG. 65

SYSTEM AND METHOD FOR IMAGE PROCESSING OF MEDICAL TEST RESULTS USING GENERALIZED CURVE FIELD TRANSFORM

TECHNICAL FIELD

[0001] The present invention relates to image processing technique, and more particularly, to image processing of medical self-test results using a generalized curve field transform.

BACKGROUND

[0002] Telemedicine is the use of telecommunication and information technology to provide clinical health care from a distance. It helps eliminate distance barriers and can improve access to medical services that would often not be consistently available in distant rural communities. It is also used to save lives in critical care and emergency situations. Although there were distant precursors to telemedicine, it is essentially a product of 20th century telecommunication and information technologies. These technologies permit communications between patient and medical staff with both convenience and fidelity, as well as the transmission of medical, imaging and health informatics data from one site to another. These telemedicine technologies provide convenient ways to obtain care from a healthcare provider, and thus, it is also desirable to have a convenient way to fill any prescriptions deemed necessary by the healthcare provider.

[0003] One manner of providing telemedicine involves the creation of images of test results for analysis. However, the test results images may include various distortions and issues causing it to be difficult to read. A manner of improving these distortions and issues would make the results much easier to analyze.

SUMMARY

[0004] The present invention, as disclosed and described herein, in one aspect thereof comprises a method for image processing medical self-test results receives a digital image of a visual indication of a test result. A digital image is generated of the visual indication of the test result that includes noise and distortions therein. The digital image is processed using generalized curve field transforms to extract relevant features of the digital image in a presence of the noise and distortions to create a transformed image. A diagnosis is generated based upon the transformed image to the plurality of images of the test results.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] For a more complete understanding, reference is now made to the following description taken in conjunction with the accompanying Drawings in which:

[0006] FIG. **1** illustrates a diagrammatic representation of one embodiment of a immunoassay test strip;

[0007] FIG. **2** illustrates a diagrammatic representation of one embodiment of an immunoassay test wherein an analyte is tested across a plurality of test strips;

[0008] FIG. **3** illustrates a diagrammatic representation of one embodiment of a testing device;

[0009] FIG. **4** illustrates a top view of the testing device of FIG. **3**;

[0010] FIG. **5** illustrates a top view of one embodiment of a testing device;

[0011] FIG. **6** illustrates a top view of another embodiment of a testing device;

[0012] FIG. **7** illustrates a flowchart of one embodiment of a testing device use method;

[0013] FIG. **8**A illustrates a diagrammatic representation of one embodiment of a process for a mobile device application for testing device image capture and image processing, wherein an image alignment indicator is not aligned with the subject of the image;

[0014] FIG. **8**B illustrates a diagrammatic representation of one embodiment of a process for a mobile device application for testing device image capture and image processing, wherein an image alignment indicator is aligned with the subject of the image;

[0015] FIG. **9** illustrates a flowchart of one embodiment of an image analysis process using a mobile device;

[0016] FIG. **10** illustrates a diagrammatic representation of another embodiment of a process for a mobile device application for testing device image capture and image processing, wherein an image alignment indicator is aligned with the subject of the image;

[0017] FIG. **11** illustrates one embodiment of a consumer driven biologic and disease data collection system;

[0018] FIG. **12** illustrates one embodiment of a consumer driven biologic and disease data collection system;

[0019] FIG. **13** illustrates an example of a unique biologic ID database table;

[0020] FIG. **14** illustrates a flowchart of one embodiment of a biologic data collection and dissemination process;

[0021] FIG. **15** illustrates a perspective view of a system for scanning test strips;

[0022] FIG. **16** illustrates a cross-sectional view of the system of FIG. **15**;

[0023] FIG. **17** illustrates one embodiment of a vertical flow immunoassay device;

[0024] FIG. **18** illustrates a cross-sectional view of one embodiment of the vertical immunoassay device of FIG. **17**;

[0025] FIG. **19** illustrates a color gradient chart;

[0026] FIG. **20** illustrates a normalized past tests results rating chart;

[0027] FIG. **21** illustrates a mobile device displaying on a screen a mobile application variable test functionality;

[0028] FIG. **22** illustrates the mobile device of FIG. **21**, wherein a housing of a testing device also includes thereon test function indicators;

[0029] FIG. **23** illustrates one embodiment of a medical code correlation system;

[0030] FIG. **24** illustrates one embodiment of a strep home retail test codes table;

[0031] FIG. **25** illustrates one embodiment of a combined pregnancy and Zika home retail test codes table;

[0032] FIG. **26** illustrates flowchart of one embodiment of a medical code correlation process;

[0033] FIG. **27** illustrates one embodiment of a telemedicine initiation option within a mobile application;

[0034] FIG. **28** illustrates another embodiment of a telemedicine initiation option within a mobile application;

[0035] FIG. **29** illustrates one embodiment of a telemedicine conference session on a mobile device;

[0036] FIG. **30** illustrates a flowchart of one embodiment of a medical file handoff process;

[0037] FIG. **31** illustrates a flowchart of one embodiment of a telemedicine conference initiation process;

[0038] FIGS. **32**A-B illustrated systems for transmitting prescriptions to a pharmacy using telemedicine;
[0039] FIG. **33** illustrates an embodiment which uses a mobile application to inform the user which prescriptions have been prescribed
[0040] FIG. **34** illustrates an embodiment which uses a mobile application to let a user decide which pharmacy will fill a prescription;
[0041] FIG. **35** illustrates an embodiment in which the user can select on a mobile application whether to pick up a prescription or have the prescription delivered;
[0042] FIG. **36** illustrates a flowchart depicting a process for filling a prescription using a self-diagnostic test and a telemedicine session;
[0043] FIG. **37** illustrates an embodiment in which a telemedicine mobile application is used to automatically fill a prescription;
[0044] FIG. **38** illustrates a mobile device from an embodiment of the system in which the user obtains a real-time health insurance quote in response to a self-diagnostic test;
[0045] FIG. **39** illustrates an embodiment of the system in which multiple insurance plans are presented through a mobile application to a user;
[0046] FIG. **40** illustrates an embodiment of the system in which more detailed information regarding a health insurance quote is presented to a user;
[0047] FIG. **41** illustrates a diagrammatic view of a system for providing real-time health insurance quotes in response to a self-diagnostic test;
[0048] FIG. **42** illustrates a flowchart depicting a process for generating a real-time health insurance quote in response to a self-diagnostic test;
[0049] FIG. **43** illustrates a side cross-sectional view of an RT-lamp;
[0050] FIG. **44** illustrates an RT-lamp with a microfluidic chip disposed in a sample chamber;
[0051] FIG. **45** illustrates a side view of a smart phone interfaced with a microfluidic chip;
[0052] FIG. **46** illustrates window view of a microfluidic chip;
[0053] FIG. **47** illustrates a diagrammatic view of a biofluidic analysis system;
[0054] FIG. **48** illustrates a diagrammatic view of an analog testing device to a digital format and unique identifier conversion process;
[0055] FIG. **49** illustrates a flow diagram providing visual analysis of medical self-test;
[0056] FIG. **50** illustrates an orientation field for associated images;
[0057] FIG. **51** illustrates a flow diagram of the generation of a generalized curve field transform;
[0058] FIG. **52** illustrates the manner for detecting lines using orientation fields;
[0059] FIG. **53** illustrates the general manner for creation of an orientation field;
[0060] FIG. **54** illustrates various alignment spectrum from for orientation fields;
[0061] FIG. **55** illustrates a flow diagram of the process for locating test strips and test pads within a sample image;
[0062] FIG. **56** illustrates a kernel used for detecting lines within an image;
[0063] FIG. **57** illustrates a located strip within an image;
[0064] FIG. **58** illustrates a located test pad within an image;
[0065] FIG. **59** illustrates a located strip region within an image;
[0066] FIG. **60** illustrates strip region line detection within an image;
[0067] FIG. **61** illustrates a block diagram of an image processing process for improving analysis of testing results;
[0068] FIG. **62** illustrates a flow diagram of an image processing process performed by an image processing system;
[0069] FIG. **63** illustrates a flow diagram illustrating image processing to remove noise and other distortions from an image;
[0070] FIG. **64** illustrates a flow diagram describing the establishment of orientation lines; and
[0071] FIG. **65** illustrates a flow diagram of the process for filtering geometric shapes from an orientation field.

DETAILED DESCRIPTION

[0072] Referring now to the drawings, wherein like reference numbers are used herein to designate like elements throughout, the various views and embodiments of a system and method for image processing of medical test results using orientation fields is described. The figures are not necessarily drawn to scale, and in some instances the drawings have been exaggerated and/or simplified in places for illustrative purposes only. One of ordinary skill in the art will appreciate the many possible applications and variations based on the following examples of possible embodiments.
[0073] Referring now to FIG. **1**, there is illustrated one embodiment of an immunoassay test strip **100**. The test strip **100** is typically housed in a testing device configured to collect a biologic analyte **106** from a user and to direct to the biologic analyte **106** onto the testing strip **100**. However, it will be understood that the biologic may be applied onto a strip **100** without the strip **100** needing to be within a testing device. The test strip **100** includes a backing **102**. The test strip **100** is made up of multiple sections disposed on the backing **102**. A sample pad **104** is disposed on one end of the strip **100**, for collecting the biologic analyte **106**. The biologic analyte **106** may be any biologic needed for use in the immunoassay, such as urine, blood, saliva, stool, sweat, or other biologics to be used as an analyte. Various methods may be used to acquire the needed biologic, and such may be provided to the user packaged with the test, such as swabs, vials, containers, dilutants and other solutions, or any other equipment required. In the case of a blood analyte, a few drops of blood may be obtained from a finger stick using a finger prick device. Such a blood analyte may be blood mixed with an adequate amount of buffered solution to create the sample analyte **106** or a blood sample that is not diluted or otherwise manipulated, in which case the blood only is the analyte **106**.
[0074] The biologic analyte **106**, after coming into contact with the sample pad **104**, begins to migrate across the strip **100** by capillary action, coming into contact with other sections of the strip **100**. A particle conjugate pad **108** is disposed between the sample pad **104** and a test line **110**. The conjugate pad **108** may contain various reagents associated with a particular antigen, such as a virus, allergen, or bacteria, the reagents being items such antibodies, enzymes, or other reagents needed to diagnose the particular condition. The reagent in the conjugate pad **108** may be conju-

gated with particles of materials such as colloid gold or colored latex beads. As the analyte **106** migrates through the conjugate pad **108**, antibodies present in the sample analyte **106** complex with the reagents in the conjugate pad **108**, thereby creating an immune complex that will migrate to the test zone or test line **110**.

[0075] The test line **110** (T) may be precoated with the relevant antigen in question, i.e., a virus, allergen, or bacteria, for the detection of antibodies associated with the particular antigen. The immune complex created when the analyte **106** passes through the conjugate pad **108** is captured onto the antigen contained on the test line **110**. This may create a qualitative response on the strip where the test line **110** is located, such as a colored response. In some embodiments, the test line **110** may not be a line, but may be other shapes or symbols, such as a plus sign. If no antigen-anti-antigen complexes are present in the analyte, no reaction occurs in the test line **110** and a qualitative response will not occur.

[0076] After passing through the test line **110**, the analyte migrates further along the strip to reach a control line **112**, where excess anti-antibody-colloidal gold or latex conjugates get bound. A qualitative response may be shown at the control line **112**, indicating that the sample has adequately migrated across the testing membrane or substrate as intended. It will be understood that the control line **112** is not necessarily needed to perform the test, and may be eliminated entirely, but the control line **112** does provide a comparative example for a user reading the test. For example, the control line **112**, in embodiments where a colored qualitative response is provided, may appear as an overly saturated color, such as a dark or bright saturated red, once the sample reaches the control line **112**. This saturated color may be used as a comparison against the qualitative response shown on the test line **110**. For example, if the qualitative response shown on the test line **110** is a much lighter red than that on the test line **110**, it may be that very little reaction occurred at the test line. Of course, if no response is shown at all at the test line **110**, no reaction has occurred. If the qualitative response at the test line **110** is of a similar saturation to the control line **112**, a strong reaction is indicated.

[0077] The strip **100** may not be a continuous substrate. Rather, the various sections of the strip **100** may be separate from each other, but all adhered to the backing **102**. As shown in FIG. **1**, the sample pad **104** and the conjugate pad **108** are separate structures from each other. The test line **100** or zone and the control line **112** or zone are both disposed as part of a nitrocellulose membrane strip **114**. The nitrocellulose membrane strip **114** is also adhered to the backing **102**, but separate from the sample pad **104** and the conjugate pad **106**. As shown in FIG. **1**, the end of the sample pad **104** adjacent to the conjugate pad **106** may overlap the conjugate pad **106**, with that end of the sample pad **106** lying over the adjacent end of the conjugate pad **106**. Similarly, the end of the conjugate pad adjacent to the nitrocellulose membrane strip **114** may lie over the end of the nitrocellulose membrane adjacent to the conjugate pad. This allows for the analyte **106** to be more easily deposited onto each section of the strip **100** as it migrates across the strip **100**. After the analyte **106** migrates across the nitrocellulose membrane strip **114**, and thus across the test line **110** and the control line **112**, the analyte **106** comes into contact with a wick **116** for absorption and collection of the analyte **106**. The end of the wick **116** adjacent to the nitrocellulose membrane strip **114** may lie over that adjacent end of the nitrocellulose membrane strip **114**, as shown in FIG. **1**.

[0078] Several Flow Immune Assays have been directed toward identifying proteins, molecules of interest, and even immunoglobulins IgG, IgA, and IgM. IgE is an antibody (immunoglobulin E) that is normally present in the blood freely circulating until it moves into the tissue where it is bound to mast cells through the receptor FcERI (F-C-epsilon-R-one) otherwise known as the high affinity IgE receptor. There is a small amount of IgE bound to IgE receptors (high and low affinity receptors) on basophils, eosinophils, and other cells in the blood and tissues.

[0079] Many assay systems are geared toward the detection of infectious proteins. All of the aforementioned tests use a non-human antibody—usually IgG type—e.g., goat IgG antibody directed against a protein of interest to detect the protein of interest from the sample (blood, urine, saliva, sweat, etc.). This antibody complexes with protein of interest and forms a complex that travels across the membrane until it reaches the test zone. In the test zone there is an IgG type antibody directed against IgG from that species of animal. As further described herein, the present detecting apparatus and method use human (patient/consumer-derived) antibodies from the sample and the test zone that contains a humanized antibody directed against the protein of interest that is preconjugated to a detecting substance that results in a visual change.

[0080] Summary of Target Antigen:

[0081] The target antigens may be proteins, glycoproteins, lipoproteins or other molecular substances capable of eliciting an immune reaction and/or being bound by human specific IgE (sIgE).

[0082] Immune Assay to Detect Specific IgE:

[0083] In the detecting apparatus and method of using the same, the antigens are proteins conjugated to a noble metal, for example, gold, or latex conjugated to antigen in the test zone, for the purpose of detecting the presence of specific IgE (e.g., anti-peanut IgE in a blood sample from a finger prick). For example, an IgG class antibody (IgG1, IgG2, IgG3, or IgG4) or fragments of those classes of antibodies (fab fragments) whose origin may be any animal species (goat, rat, human, etc.) capable of detecting human IgE (anti-IgE IgG)—a suitable commercially available humanized antibody, such as omaluzimab may be used—may be used to form immune complexes of IgG-anti-IgE-sIgE that will migrate to the test zone having selected specific IgE that can bind to the conjugated antigen.

[0084] Immune Assay to Detect Total IgE (not Concerned about Specific IgE):

[0085] Another embodiment includes using an IgG class antibody (IgG1, IgG2, IgG3, or IgG4) or fragments of those classes of antibodies (fab fragments) whose origin may be any animal species (goat, rat, human, etc.) capable of detecting human IgE (anti-IgE IgG)—a suitable commercially available humanized antibody that is preconjugated to a detecting molecule that results in a color change when bound to IgE as the target antigen in the test zone.

[0086] Referring now to FIG. **2**, there is illustrated one embodiment of an immunoassay test **200** wherein an analyte **202** is tested across a plurality of test strips **204**. The plurality of test strips **204** may each be configured for testing

for a particular antigen. For instance, one strip may be for testing for the presence of streptococcal bacteria (strep throat), one strip may be for testing for a peanut allergy, one strip may be for testing for the Zika virus, etc. Additionally, each strip may also test for multiple antigens. For example, as shown in FIG. **2**, multiple testing panels or lines maybe be incorporated. Each line may be for a particular antigen. As shown in FIG. **2**, multiple test lines **206**, **208**, and **208** may be disposed along the plurality of strips **204**. A strip testing for allergens may have a panel for testing for peanut allergies shown at test line **206** (CH**1**), for cat allergies shown at test line **208** (CH**2**), or grass allergies shown at test line **210** (CH**3**).

[0087] Other examples of configurations for the testing panels can be, but are not limited to: 1) Food 5: Peanut, milk, soy, wheat, egg; 2) Nut and seed panel: almond, cashew, hazelnut, peanut, pecan, walnut, sesame seed, sunflower seed; 3) seafood: crab, lobster, shrimp, salmon, tuna; 4) Pets: cat, dog; 5) Indoor allergens: dust mites, mold mix (*Alternaria, Aspergillus, Penicillium, Cladosporium*), cat, dog; and 6) seasonal allergens: grass (Bermuda, bahia, Johnson, rye, timothy), trees (oak, elm, cedar, mesquite, pine, etc.), weeds (pigweed, ragweed, sage, Russian thistle).

[0088] With respect to other non-allergen antigens, the panels may be for testing for strep, Zika, flu, anthrax, cold viruses, cancer, HPV, Lyme disease, mononucleosis (mono), and other illnesses, and/or other conditions such as pregnancy (hCG detection) and disease risks. Some embodiments may allow for the testing of various arboviruses (arthropod-borne viruses). Arboviruses are viruses that are transmitted by arthropods, with mosquitos being a common vector for the virus. Vectors are organisms that transfer the virus from a host that carries the virus. Thus, in the case of mosquitos, a mosquito that feeds on a host that is infected with a virus may infect others when that mosquito again feeds on an uninfected host. Well-known arboviruses include Dengue virus, Japanese encephalitis virus, Rift Valley fever virus, West Nile virus, yellow fever virus, chikungunya, and Zika virus. Urine, blood, and saliva and other biologics may be used for arboviruses testing.

[0089] Certain antigens or medical conditions may be logically paired together. For instance, a testing device may include both a strip for detection of pregnancy and a strip for the detection of the zika virus, as the Zika virus has been known to cause birth defects in infants born to pregnant women that are infected with Zika. Thus, combining these two tests into a single testing device or kit would alert a woman to a potential Zika infection proximate in time to the time she also discovers she is pregnant, allowing the woman to seek medical attention immediately. This is a substantial improvement over past Zika testing, where a woman may be required to wait weeks before results are returned from a lab after having the biologic collected by her physician. In many cases, this may lead to a woman having passed a state-mandated cutoff point for abortions, such as 24 weeks in some states. Combining a Zika test with a pregnancy test and physically linking the two tests, and thus allowing for a woman to determine a Zika risk at the time of taking a pregnancy test, in which a pregnancy test may be taken as soon as six days after conception, allows for that woman to take action much sooner than the state mandated cutoff and waiting for lab results would allow.

[0090] Various testing devices that include the test strip **100** or strips may be used, such as a slide that supports the test strip **100**, a cassette based diagnostic test, a dipstick, or combinations thereof. The test results in various embodiments may be in the form of a visual qualitative reading test, a visual semiquantitative format, a reader quantitative assay format, and/or combinations thereof. Additionally, an electronic implementation may be used where the result is displayed digitally on a screen disposed within the apparatus, and visible to the user.

[0091] The apparatus and method of detection may be a "one-step" approach from sample to reading without sample dilution or other sample manipulation. The sample may be diluted or endure other sample manipulation, for example the blood sample is diluted with a buffer.

[0092] Referring now to FIG. **3**, there is illustrated a diagrammatic representation of one embodiment of a testing device **300**. The testing device **300** includes a housing **302** that forms the body of the testing device. The housing **302** may be made of plastic, metal, or any material durable enough for shipping and subsequent handling by a user. The housing **302** may be hollow so that a plurality of test strips **304** may be housed within and so that a biologic may be deposited within the housing **302**. The testing device **300** may further have a plurality of windows **306**, each window being associated with one of the plurality of test strips **304**, and allowing for a user to view at least the section of the nitrocellulose membrane strip **114** where the test line **110** and control line **112** are located. The plurality of windows **306** may be open, or covered with plastic, glass, or other materials that allow for viewing the plurality of strips **304**. A sample well **308** may be disposed on a surface of the housing **302** to allow a user to deposit a biologic into the housing **302**. The sample well **308** would be disposed over or near the sample pad **104** of the test strip or strips **100**. In the embodiment shown in FIG. **3**, a single sample well **308** is included for collection of a single type of biologic for testing, with each of the plurality of strips **304** being suited for testing for antigens using that particular biologic sample type. For example, if the testing device **300** is a combined pregnancy and Zika test, having both a pregnancy strip and a Zika strip, a urine sample may be deposited into the sample well **308**, causing the urine sample to come into contact with the sample pad **104** on both the pregnancy strip and the Zika strip. It will be understood that both of these tests may also be performed with a blood sample.

[0093] The testing device **300** may also have disposed on the surface of the housing a crosshair symbol **310**, used as an alignment target. This symbol may be a graphic printed or adhered to the testing device **300**. The crosshair symbol **310** is used to align the testing device **300** for the taking of an image of the testing device **300** using a camera on a mobile device, for use in a mobile device application described herein. In other embodiments, the crosshair symbol **310** may be other types of symbols, such as a simple shape (circle, square, etc.), other images (such as a medical cross symbol, an arrow, etc.), or any other type of image.

[0094] Referring now to FIG. **4**, there is illustrated a top view of the testing device **300**. There is again shown the housing **302**, the plurality of test strips **304**, the plurality of windows **306**, the sample well **308**, and the crosshair symbol **310**.

[0095] Referring now to FIG. **5**, there is illustrated a top view of one embodiment of a testing device **500**. The testing device **500** includes a housing **502** having a plurality of test strips **504** within the housing **502** and a plurality of windows

506 for display of the plurality of strips **504**. The housing **502** also includes a plurality of sample wells **508** disposed on one side of the testing device **500**. Each of the plurality of sample wells **508** is associated with one of the plurality of test strips **504** and each of the plurality of sample wells **508** may be disposed over one of the sample pads **104** on the associated one of the plurality of test strips **504**. This allows for a biologic to be deposited into each of the plurality of sample wells **508**, with each well **508** serving to transfer the biologic to the test strip underneath the sample well. The testing device **500** further includes a crosshair **510**. The crosshair symbol **510** is used to align the testing device **500** for the taking of an image of the testing device **500** using a camera on a mobile device, for use in a mobile device application described herein.

[0096] Referring now to FIG. **6**, there is illustrated a top view of another embodiment of a testing device **600**. The testing device **600** includes a housing **602** having a plurality of test strips **604** within the housing **602** and a plurality of windows **606** for display of the plurality of strips **604**. The housing **602** also includes a plurality of sample wells **608**. In this embodiment, the sample wells are located on different ends of the housing **602**. In the case of a two test strip device, the sample wells **608** are disposed on opposite ends of the testing device **600**. The strips **604** would be arranged within the housing in such a way as to allow the sample pad **104** on each of the strip to be disposed underneath one of the sample wells **608**. This is useful for testing devices that require different biological samples. For example, if the testing device **600** required a urine sample for one strip and a blood sample for the other strip, having the wells **608** disposed on opposite sides of the testing device would reduce the likelihood that a urine sample, for instance, might be inadvertently deposited into the well designated for the blood sample. In embodiments where there are more than two strips, and more than two wells, the well positions may alternate between the two sides of the testing device. For instance, a first well for a first strip might be disposed on the left side of the testing device, a second well for a second strip might be disposed on the right side of the testing device, a third well for a third strip might be disposed on the left side of the testing device, a fourth well for a fourth strip might be disposed on the right side of the testing device, and so on. The testing device **600** further includes a crosshair **610**. The crosshair symbol **610** is used to align the testing device **600** for the taking of an image of the testing device **600** using a camera on a mobile device, for use in a mobile device application described herein.

[0097] The diagnostic test can, for example, be produced in a various formats for different users, such as, but not limited to, consumer/in-home use where the test is purchased through retail channels which will allow individuals to get an immediate, cost-effective test result that can lead to specific avoidance and treatment through follow-up with a medical professional.

[0098] The diagnostic test can be provided to and used by hospitals and clinics to provide rapid, on-site test results that are required to prescribe certain medications, such as omaluzimab, by their FDA labels.

[0099] This diagnostic assay can be modified to detect the presence of specific IgE in pets.

[0100] It is also noted that housing **602** is designed such that both strips **604** are disposed in physical proximity thereto and in the same actual housing. In this manner, both sets are linked physically to each other such that they cannot be separated and can be associated with a single individual and the actual test cannot be separated. As such, when a patient applies the specimens to the two areas **608** and the test results are exhibited, there is a high probability that two tests were performed at the same time associated with the same patient. Additionally, and electronic chip (not shown) can be embedded within the housing **602** such that the housing **602** can be registered to a specific patient and associated with the medical records of that patient.

[0101] Referring now to FIG. **7**, there is illustrated a flowchart of one embodiment of a testing device use method **700**. The method **700** begins at step **702** where a biologic is collected in a sample well or wells of a testing device. The biologic collected may be a non-diluted or non-manipulated biologic, such as blood, urine, or saliva from the user of the test. Diluted or manipulated biologics may be used instead, as required by the specific test. For example, if a viral test requires the biologic to be added to a solution, the biologic could be added to a solution that has previously been placed in a sterilized vial provided with the testing device. After the required amount of time has passed, the solution containing the biologic could be deposited into the well or wells. At step **704**, the biologic contacts a sample pad disposed on a strip or strips within the testing device. At step **706**, the biologic migrates along the strip or strips to come into contact with a conjugate pad containing antibodies. Antibodies present in the biologic will complex with the antibodies in the conjugate pad to create an immune complex. At step **708**, the biologic migrates into a test zone of the strip or strips, coming into contact with an antigen. The antibodies in the conjugate pad serve to provide a means of detection, such as a colored response, if the immune complex binds with the antigen present in the test zone of the strip. At decision block **710**, binding of the antibodies with the antigen may or may not occur depending on if antibodies associated with the antigen are present in the biologic or not. If a binding between the antibodies and the antigen does not occur the process moves to step **712** where no qualitative response is produced on the test line. If a binding does occur, at step **714** a qualitative response is produced on the test line. Whether a binding occurs or not, and whether a qualitative response is produced or not, the process moves to step **716** where the biologic migrates into a control zone of the strip or strips where excess conjugates get bound and produces a qualitative control zone reaction indicating that the sample has adequately migrated across the testing zone.

[0102] It will be understood by one skilled in the art that the antibodies and antigens applied to the testing strip may be altered depending on the type of condition being tested. For example, in the case of testing for medical conditions that do not involve an illness or infection, like pregnancy, and thus the sample biologic does not contain antibodies associated with the condition, antibodies that react to markers being tested for may be applied to the testing strip instead of an antigen. For instance, pregnancy test requires testing for the presence of hCG. Since hCG is a hormone and not an antibody produced in response to an infection, the testing strip may have antibodies that will react to the presence of hCG applied to the testing zone or line of the testing strip, as well as to the conjugate pad. Similarly, some tests might require antibodies be applied to the testing strip to detect antigens present in the sample, rather than antibodies.

[0103] Referring now to FIGS. **8**A and **8**B, there is illustrated a diagrammatic view of one embodiment of a process **800** for a mobile device application for testing device image capture and image processing. The mobile device application allows for an image of a testing device, such as testing device **300**, to be captured using a camera installed on a mobile device **802** having a screen **804**. While the mobile device **802** displays on the screen **804** the scene captured by the camera, the mobile device application also displays a graphic on the screen **804** in the form of a boxed outline **806**, the size of the outline **806** corresponding to the size of the testing device **300**. Also displayed on the screen of the mobile device **802** within or near the outline is a crosshair graphic **808**. A user of the mobile device **802** attempts to align the outline **806** with the borders of the testing device **300** and also attempts to align the crosshair graphic **808** with the crosshair **310** on the testing device **300**. While alignment has not yet been achieved, a misalignment warning **810** may appear on the screen of the mobile device **802**, indicating to the user that alignment has not yet been achieved. Such is shown in FIG. **8**A.

[0104] In FIG. **8**B, there is shown the result of a successful alignment of the outline **806** with the testing device **300** and successful alignment of the crosshair graphic **808** with the crosshair **310** on the testing device **300**. As shown in FIG. **8**B, once aligned, a success indicator **812** may appear, such as a check mark or other positive status symbol, on the aligned image. Successful alignment causes the camera on the mobile device **802** to capture the current image of the testing device **300**. Other checks may occur, including ensuring that the image is focused before the image is saved. This image is then processed to determine a result based on the severity of the reaction occurring on the test strip. The mobile device application performs an analysis of the test line captured in the image, counting the number of colored pixels, as well as determining the intensity of the color. The mobile device may then compare this number and color intensity to that in the control line, providing a mathematical evaluation of the test line. Utilizing unique wavelengths of light for illumination in conjunction with either CMOS or CCD detection technology, a signal rich image is produced of the test lines to detect the colloid gold or latex particles. This provides an advantage because a user simply looking at the two lines may not know what the test line indicates, such as when the colored line does appears on the strip, but it is a faded line, rather than a dark line. Based on this analysis, the mobile device application may provide a results indicator **814**.

[0105] The results indicator **814** may be a qualitative result or a quantitative result. For example, and as shown in FIG. **8**B, a qualitative result for the results indicator **814** may indicate, in the case of a testing device for testing pregnancy as well as an infection, a plus sign next to a line reading "pregnant:" and a plus sign next to a line reading "infection:" to indicate that the user is both pregnant and infected with the bacteria or virus being tested, such as the Zika virus. For a quantitative result, the results might provide a numeric rating. For instance, a rating system between 1-100 may be used. If the results provide a low rating to the user, such as a rating of 10, this indicates a low risk of infection, although medical attention may be sought by the user anyway. For example, if the user is pregnant, and also receives a 10 rating for Zika, this may indicate that Zika was detected in low amounts. However, the user may still seek medical attention or further testing from her doctor because Zika has been known to cause birth defects. If the rating is a high rating, such as 95, this indicates that an infection has most likely occurred and medical attention should be sought immediately.

[0106] This same quantitative rating system may be applied to any test (viral infections, bacterial infections, pregnancy, and other health conditions), as the quantitative test can be performed using the software described herein to accurately test bound antibody concentrations on the test strip. In some embodiments, a combined qualitative and quantitative result may be presented, such as both a rating and a plus or minus sign being presented, or other types of quantitative and qualitative indications. Additionally, various combinations of tests may be provided for in the testing device, such as pregnancy/Zika, pregnancy/flu, pregnancy/strep/Zika, etc.

[0107] Referring now to FIG. **9**, there is illustrated a flowchart of one embodiment of an image analysis process **900** using a mobile device. At step **902** a mobile device application is launched. At step **904** a camera on the mobile device is activated and a crosshair indicator and a testing device outline appear on the mobile device screen. At step **906** the crosshair indicator presented on the screen of the mobile device is aligned with a crosshair icon on the testing device and the device outline presented on the screen of the mobile device is aligned with the borders of a testing device. At step **908**, an indicator of successful alignment is presented on the screen and an image of the testing device is taken by the mobile device camera. At step **910**, the mobile device application processes the image of the testing device to determine test line strength by counting the number of colored pixels contained in the test line. At step **912**, the mobile device application correlates line intensity with analyte concentrations to further determine test line strength. At step **914**, the mobile device application presents the test results based on pixel count and line intensity, providing either a qualitative or quantitative result.

[0108] In some embodiments, the number of pixels indicating bound antibodies on the strip may be measured against that in the control line to compare line intensity between the two lines, with the control line acting as an example of a strong reaction, indicating a strong infection, and determining how close the test line intensity is to the control line. This would lead to a logical quantitative result. For instance, if the test line is determined to have a pixel count and line intensity that is 25% of the pixel count and line intensity of the control line, a rating of 25 may be given. If a qualitative result is to be provided, a rating of 25 may give a qualitative result that is negative, or it could be positive depending on the type of condition being tested and known actual infection results where a rating of 25 occurred for that condition.

[0109] In some embodiments, the test line may not be compared with the control line to determine a result. Rather, the mobile device application may have access to a database having data on numerous past tests for the same condition. This data may instead be used as the control. This allows the application on the mobile device to retrieve data on past tests and compare the test line data of the current test to past tests. Overall data for past tests may be provided and compared against, such as providing an average or a grading curve of past tests, or individual tests rated as having accurate results may be compared against.

[0110] In addition to a status result of an infection or other medical condition being provided to the user, other indicators of health may also be tested and results thereon provided. This provides for potential early identification of pregnancy and risk of morbidity, allowing for medical attention to be sought much more quickly. Indicators of health may be detected from biologics, such as urine and blood. Urine, for example, allows for the detection of glucose levels, proteins, bacteria, and infectious markers. In the case of glucose, glucose is usually not found in urine, but, if it is, that is an indicator of extremely high levels of glucose in the body, where the kidneys release excess glucose into urine. This is often a sign of diabetes. Protein in the urine may indicate a malfunctioning of the kidneys, which could be the result of high blood pressure. Similarly, if blood is detected in urine, it could be a sign of a problem with the kidneys or the bladder. Blood, for example, allows for the detection of glucose, inflammation, hormones, genetic defect risks, and metabolic endocrine disorders.

[0111] Referring now to FIG. **10**, there is illustrated another embodiment of a successful alignment of the outline **806** with the testing device **300** and successful alignment of the crosshair graphic **808** with the crosshair **310** on the testing device **300**, wherein quantitative results for health risk indicators are provided. In this embodiment, the results indicator **814** provides a qualitative result for pregnancy, and quantitative results for other health risk indicators. In the embodiment shown in FIG. **10**, the health risk indicators being tested are markers for blood pressure and for glucose levels. For blood pressure, this is a test for markers in the blood that can be associated with high blood pressure. These could be test for such things as low levels of vitamin D and the such. Studies have shown that patients suffering from essential hypertension will be under oxidative stress and Malondialdehyde (MDA) is the principal and most studied product of polyunsaturated fatty acid pre-oxidation. This can show an indirect correlation with anti-oxidants, particularly with superoxide dismutases (SODs) (r=0.573) and catalase (r=0.633) representative anti-oxidant are involved in reducing the stress of a patient's biological system during hypertension. Another marker for hypertension is buildup of uric acid, where in uric acid is a marker for xanthine oxidase-associated oxidants and that the latter could be driving the hypertensive response. Additional markers are cortisol, a hormone. The test strips **604** can test for the different biological markers.

[0112] The results indicator **814** provides numeric ratings, in this case, 1-100, with the blood pressure rating being 88 and the glucose rating being 95. This indicates that both blood pressure and glucose are extremely high. Due to this, an additional alert indicator **1002** is presented to the user on the screen of the mobile device, alerting the user to seek medical attention immediately. This is to ensure that the health of both the pregnant woman and the fetus can be checked as close to the time of pregnancy detection as possible and medical attention received if needed.

[0113] Referring now to FIG. **11**, there is provided a flowchart of one embodiment of a pregnancy disease risk assessment process **1100**. The process **1100** begins at step **1102** where a biologic is collected and deposited in a testing device for testing of the biologic. At step **1104**, the biologic is processed by the testing device for detection of pregnancy and various other medical conditions. These medical conditions may be high blood pressure, diabetes, bacterial or viral infections, inflammation, an increase in hormone levels, genetic disease markers, and/or metabolic disorders. At step **1106**, a mobile device is used to capture an image of the testing device after testing is complete. In some embodiments, test results may be immediate. In other embodiments, and depending on the medical conditions being tested, the test may take a certain amount of time to complete. In this case, the user of the test would be alerted to this fact in instructions provided with the testing device. Additionally, a visual indicator on the testing device may alert the user that a test is now complete. At step **1108**, the mobile device provides a rating for each medical condition being tested, such as that described with respect to FIG. **10** herein.

[0114] At decision block **1110**, it is determined whether the ratings for each condition exceed a certain threshold for that condition. If not, the process **1100** moves to step **1112**, where an indication is presented to the user via the mobile device screen that medical attention is not currently advised or necessary. If at step **1110** it is determined that at least one of the medical conditions being tested rises above a certain threshold, the process **1100** moves to step **1114** where a warning is presented to the user via the mobile device screen that medical attention is advised. The thresholds for medical conditions may not trigger a warning even if a rating exceeds a threshold, if, in the event of multiple tests being performed, the combined test results do not warrant immediate medical attention. For example, if a user is testing for a cold virus, blood pressure, and glucose, and only the cold virus rating is above the threshold, there may not be a warning provided to the user. Additionally, ratings may be weighted or aggregated based on the medical conditions being tested. For example, if blood pressure, inflammation, and glucose are being tested for, and they all are given only moderate ratings that do not rise above the threshold for any condition individually, an warning to seek medical attention may still be provided due to the combination of conditions taken together.

[0115] Referring now to FIG. **12**, there is illustrated one embodiment of a consumer driven biologic and disease data collection system **1200**. Data collected from users performing the tests disclosed herein effectively can provide a wealth of information. As tests are performed data may be passed by a plurality of mobile devices **1202** being used by users performing tests to a database **1204**, the database being at a remote server **1206**, over a network **1208**. The user is sourcing a biologic from user's own body. This is done at home, not in a lab, hospital, or clinic. Each particular test would expect a certain type of biologic to be provided. For instance, for a pregnancy test, a urine sample is provided and tested for pregnancy markers. For a stool test, the stool might be dissolved in a vial with a solution provided with the testing device/kit, and tested for various disease or infectious markers. Data and results from the tests may be stored on the database **1204** at the remote server **1206**. As described herein, this data may be used as a control for testing analysis for users of the plurality of mobile devices **1202**. This data may also be used to provide data sets for biologics to a medical organization **1210**. The medical organization **1210** may be doctor's offices, researchers, hospitals, testing labs, and other individuals or organizations that have an interest in the health and analysis of users taking the test and of their biologic samples. In this way, data can be gathered from a variety of biologics tested for a variety of different medical conditions and characteristics.

[0116] Referring now to FIG. **13**, there is illustrated an example of a unique biologic ID database table **1300**. The table **1300** is illustrative of the type of data stored in association with data for a biologic transmitted by the plurality of mobile devices **1202** for storage on the database **1204**. A biologic ID header **1302** is provided that shows that the biologic sample has been given a unique ID. All data concerning the biologic may be stored in association with the unique biologic ID. The table **1300** also includes a biologic type entry **1304**. This designates what type of biologic that the biologic associated with the unique ID is, such as blood, urine, stool, saliva, sweat, or other biologics. The table **1300** also provides a plurality of test ratings **1304**, for various tests performed on the biologic. In the example shown in FIG. **13**, a blood biologic is provided having an assigned ID of **2402**, and having been testing for pregnancy markers, the Zika virus, and for glucose levels. The rating for pregnancy was a 99 rating, the rating for a Zika infection was a 75, and the rating for glucose levels was a 10. This would indicate that the test subject has an extremely high likelihood of both a pregnancy and a Zika infection, which would have resulted in a warning to seek medical attention at the conclusion of the tests. Other information may also be stored in the database in relation to the biologic, including other condition ratings, time and date each test was performed, user information such as ethnicity, gender, and age, and status indicators such as whether a test subject visited a physician as a result of the tests. The database **1204** thus provides the test subject with a growing collection of information that may be accessed by the test subject. This allows the test subject to present the test results to her physician for medical attention or additional testing, and allows for others who may access the database, such as disease researchers, to have access to data on various biologic samples and their markers.

[0117] Referring now to FIG. **14**, there is illustrated a flowchart of one embodiment of a biologic data collection and dissemination process **1400**. The process **1400** begins at step **1402** where a user of a testing device collects a biologic sample for use in a test or a series of tests. At step **1404**, the test or series of tests are performed on the biologic sample. At step **1406**, a mobile device application checks the biologic sample the testing device result to determine a quantitative result of the test to provide a correlative value for the condition being tested in the biologic sample. At step **1408**, the test results and correlative values, or multiple values if multiple tests on the biologic sample were conducted, are transmitted to the remote server **1206**. At step **1410**, the biologic sample is given a unique identification number in the database **1204**. At step **1412**, the test results and correlative value or values are stored in the database **1204** in association with the unique identification number given to the biologic sample collected and in association with the particular tests performed. This way, the particular biologic sample may have various characteristics stored and retrieved in association with the biologic sample, and the test results may also be retrieved when data on a particular test is needed on a cross-section of users.

[0118] At step **1414**, the results are provided to the user on the user's mobile device. At step **1416**, the results are provided to the user's healthcare provider. The healthcare provider may receive the test results due to a visit from the user, the user bringing the results of the test with her on her mobile device, or the healthcare provider may receive the results from the database **1204** if the healthcare provider has permission to access the database **1204**, or if access is granted in anticipation of the user's appointment with the healthcare provider. At step **1418**, the test results are also provided to other healthcare industry individuals and organizations, including medical researchers, hospitals, and others.

[0119] Referring now to FIG. **15**, there is illustrated a perspective view of a system for scanning test strips. The housing **604**, as described hereinabove with respect to FIG. **6**, is illustrated as being disposed within a slot **1502** in a test housing **1504**. The test housing **1504** is connected through a line **1506** to a PC **1508**. When the housing **604** containing the test strips **604** after being subjected to the biologics is inserted within the slot **1502**, the test housing **1504** will scan the test strips **604** and analyze the results with the PC **1508**. The PC **1508** will run some type of algorithm that can analyze the results of both of the test strips **604**. There can be provided to indicators **1510** and **1512** on the surface of the test housing **1504**, one being, for example, a ready LED and one being a green LED. The PC **1508**, after analyzing results, can then provide a warning indicator such as lighting up the green LED for a positive indication of pregnancy and the red LED for indicating that there is some issue. As an example, suppose that the second test strip tested for the Zika virus. If so, a warning would be appropriate to output and activate the red LED. There could be any other type of indicator associated with the second test at **604** that, in a combination with the test results of the first test strip, i.e. for testing for the presence of a pregnancy state, testing for such things as diabetes, etc. Further, although only two test strips **604** are illustrated, there could be multiple test strips testing for many different biological issues that may be present in an individual. In this embodiment, by inserting the housing **602** into the test housing **1504** and allowing the PC **1508** to analyze the results, the indicators associated with the test strips can be analyzed with the assumption that all of the test return results were associated with an individual and in proximate time to each other. That means that the individual patient applied biological specimens, such as urine, blood, etc., to the appropriate test strips and, since these were all contained within the same test strip housing **602**, this provides an indication that they are associated with a single patient. Further, the test performed will typically be a test that will provide a very short-term response. Thus, the specimens can be applied to the test strips **604** in the test strip housing **602** and then inserted within the slot **1502** for testing by the PC **1508**.

[0120] Referring now to FIG. **16**, there is illustrated a cross-section of the test housing **1504**. It can be seen that the test strip housing **1602** is passed in slot **1502** past the camera **1602**. The camera **1602** is operable to scan a small cross-section of the test strips **604** on the surface thereof as the test strip housing **602** passes thereby. Of course, there could also be a much larger camera provided for taking an entire image of the test strips **604** after being inserted within the test housing **1504**. The camera **1602** is connected via a wire **1604** two in electronics package **1606** to process the information and send it to the PC **1508**. The electronics package **1606** will also drive the indicators **1510** and **1512**.

[0121] Referring now to FIG. **17**, there is illustrated one embodiment of a vertical flow immunoassay device **1700**. It will be understood that testing device **300** and other embodiments herein illustrate a lateral flow immunoassay device.

However, other types of immunoassay devices may be used. For example, vertical flow immunoassay devices may be used, a two-sided flow through assay, or even a sandwich ELISA test may be run.

[0122] The testing device **1700** includes a housing **1702** that forms the body of the testing device. The housing **1702** may be made of plastic, metal, or any material durable enough for shipping and subsequent handling by a user. The housing **1702** may be hollow so that a plurality of immunoassay test pads **1704** may be housed within and so that a biologic may be deposited within the housing **1702**. The testing device **1700** may further have a plurality of sample wells **1706**, each sample well having one of the plurality of immunoassay test pads **1704** disposed within, and allowing for a user to view at least a section of a nitrocellulose membrane of each of the immunoassay test pads **1704**, the membrane **1708** having a test line **1708** and control line **1710**. The testing device **1700** may also have disposed on the surface of the housing a crosshair symbol **1712**, used as an alignment target. This symbol may be a graphic printed or adhered to the testing device **1700**. The crosshair symbol **1712** is used to align the testing device **1700** for the taking of an image of the testing device **1700** using a camera on a mobile device, for use in a mobile device application described herein. In other embodiments, the crosshair symbol **1712** may be other types of symbols, such as a simple shape (circle, square, etc.), other images (such as a medical cross symbol, an arrow, etc.), or any other type of image. In other embodiments, the device **1700** may be configured in such a way as to allow a biologic sample to be deposited into a sample well, and to present the results of the test on the opposite side of the housing. Such a configuration would allow the biologic to flow through the testing pad within the housing, with the reaction occurring on a reactive membrane on the side of the device opposite the sample well, with the device having a window for viewing the results.

[0123] Referring now to FIG. **18**, there is illustrated a cross-sectional view of one embodiment of the vertical immunoassay device **1700**. There is shown one of the plurality of immunoassay test pads **1704** residing within the housing **1702** below one of the plurality of sample wells **1706**. The one of the plurality of immunoassay test pads **1704** includes a immunoreactive membrane **1802**, such as the nitrocellulose membranes disclosed herein. The immunoreactive membrane **1802** may have particle conjugates disposed thereon that binds when a biologic sample is received onto the immunoreactive membrane **1802** via the sample well **1706**, if the biologic sample contains the antigens or antibodies, or other indicators, for which the test is configured. The one of the plurality of immunoassay test pads **1704** also includes an absorbent pad **1804** for collection of excess biologic sample. It will be understood that the cross-sectional view illustrated in FIG. **18** shows one well of the plurality of sample wells **1704**. The other wells included in the device **1700** would be configured in a similar manner as that shown in FIG. **18**. There may also be included in the device **1700** an inner separating wall between each of the plurality of immunoassay test pads **1704**, to ensure that excess biologic material that is not adequately absorbed by the absorbent pad **1804** does not contaminate neighboring immunoassay test pads.

[0124] Referring now to FIG. **19**, there is illustrated a color gradient chart **1900**. When the mobile application described herein captures an image of the testing device, in some embodiments each pixel that makes up the test line captured in the image is processed to place it on a color gradient scale. In some embodiments, this placement may be done by examining the RGB values of the pixel. For any given test, there may be a visual color indicator (such as a test line) presented to the user of the test to indicate whether a reaction occurred. The color that is to be presented is known for the given test. Additionally, in some embodiments, the strength of the reaction will affect the strength of the color indicator. For example, if a test is supposed to produce a brown colored indicator, an image can be taken of the colored indicator to examine each pixel of the colored indicator to determine the strength of the color produced on the testing device, which indicates the strength of the reaction, and thus the risk level for the user.

[0125] Referring now to FIG. **20**, there is illustrated a normalized past tests results chart **2000**. The captured pixels may be normalized into a single value for determining whether there is a likelihood of infection, pregnancy, or whatever else the test is designed to detect. This may be done in various ways. For example, the shade of red in all the pixels may be averaged to reach a single RGB value. Outliers may be left out so that the average is not heavily skewed, especially when there are few outliers present. This RGB value may then be given a value, such as a risk rating, ranging from 0 to 100. For example, an RGB value of (255, 255, 255) would be given a rating of 0. An RGB value of (255, 0, 0) would be given a rating of 100. An RGB value of (205, 150, 75) may be given a rating of 70, and so on. This normalized value may then be used to compare the user of the test to users of past tests to determine a risk level. In some embodiments, the control line and the test line may be captured and the results compared, as well. In addition, the real results of risk levels may also be used to adjust the stored normalized value. For instance, if a particular RGB value that seems to indicate a strong reaction repeatedly was found to not indicate an infection, this value may be adjusted to provide a lower risk rating. For instance, if a physician who saw a patient who had a (205, 150, 75) RGB value later reported to the operator of the server **1206** that further testing showed no infection was present, and if this trend continued substantially as reported by other physicians or medical organizations, subsequent test results by other test users that were near the RGB value of (205, 150, 75) may be given a lower rating.

[0126] Chart **2000** illustrates how past tests results may be collected and used to determine the risk of a current test user. A y axis **2002** represents a risk level rating, ranging from 0 at the origin to 100. An x axis **2004** represents time, wherein a plurality of normalized test results is plotted on the chart **2000**. The chart **2000** is further divided into sections across the y axis **2002**, indicating various risk level thresholds. For instance, and as illustrated in the chart **2000**, there may be at certain rating levels different thresholds of risk labeled as low, moderate, above average, and high risk levels. These thresholds may be moved over time as more data is accumulated via users conducting tests and the mobile application storing the data on the tests. When a user conducts a test, the user's normalized rating can be plotted similarly to past test results and weighed against them in order to provide a risk level for the user.

[0127] Referring now to FIG. **21**, there is illustrated the mobile device **802** displaying on the screen **804** a mobile application variable test functionality. There is displayed on

the screen **804** a plurality of test functions **2102**. The plurality of test functions **2102** may be buttons that can be selected by a user to switch between tests within the mobile application. This allows for all test functions to be within the same mobile application. For each test run by the mobile application, data for the particular test chosen is utilized in performing the test, pulling the data from the remote server **1206**.

[0128] Referring now to FIG. **22**, there is illustrated the mobile device **802** of FIG. **8**B, wherein the housing **302** of the testing device **300** also includes thereon test function indicators **2202** and **2204**. The test function indicators **2202** and **2204** are visual markers located on the housing **302** that identify to the mobile application the types of tests for which the testing device **300** is configured. These indicators may be any symbol, alphanumeric character, shape, etc. that can be added to the surface of the testing device **300**. The mobile application is programmed to recognize the indicator and perform the test function associated with the indicator. For example, the embodiment illustrated in FIG. **22** shows a "P" symbol for test function indicator **2202** and a "Z" symbol for test function indicator **2204**. In this embodiment, test function indicator **2202** indicates that one test strip in the testing device **300** is a pregnancy test, while test function indicator **2204** indicates that one test strip in the testing device **300** is a Zika test. This is used for merely illustrative purposes, and any recognizable symbol may be used for these two test functions, and any other type of test may have a symbol assigned in this way as well. Further, in some embodiments there may only be one indicator on the housing **302**, even if there are multiple tests. This single indicator would be for the combined test. For example, if the testing device **300** of FIG. **22** had a single symbol of "PZ," this would indicate that the testing device **300** is a combined pregnancy and Zika testing device, allowing for the mobile application to recognize such and perform each test with knowledge of which strip is associated with which test based on the stored data on the testing device associated with the "PZ" symbol.

[0129] Referring now to FIG. **23**, there is illustrated a medical code correlation system **2300**. The system **2300** includes a mobile device **2302**, which is configured to run the mobile application described herein. The mobile device **2302** is connected to a database **2304** disposed on a server **2306**, over a network **2308**. To correlate a medical code, the mobile device first passes a diagnostic test identifier to the remote server. This identifier allows for the type of test being used by the user of the mobile device **2302** to be determined. The identifier may simply be the name of the test, may be a number associated with the test, or any other means of identifying the test being performed by the user of the mobile device **2302**. This may be done when the phone capture the image of the testing device to process the results, or the user may enter the test to be performed before a test is conducted, at which time the mobile device **2302** may pass the identifier to the remote server. In other embodiments, the diagnostic test identifier may even be the medical code. For example, if the diagnostic test is a strep test, the identifier may be G0435, an HCPCS code for a rapid immunoassay test, or any other appropriate medical code.

[0130] Once the physical test results of the diagnostic test is captured, and once the results are processed by the mobile device **2302** or the server **2306**, the results are also received by the server. Once the server **2306** has the diagnostic test identification and the results of the test, the server **2306** may then correlate the specific test and the results with appropriate medical codes stored within the database **2304**. It will be understood that the database **2304** may be physically located with the server **2306**, or the database **2306** may be a remote database, such as a centralized database that allows entities within the healthcare industry to retrieve the latest medical codes. The medical codes assigned may then be transferred from the mobile device **2302** to a healthcare entity **2310**. In other embodiments, the medical codes may be transferred from the server **2306** to the healthcare entity **2310**. The healthcare entity **2310** may be a physician, a hospital, a pharmacy, an insurance company, or any other entity that may provide the user with further assistance.

[0131] Referring now to FIG. **24**, there is illustrated a strep home retail test codes table **2400**. The table **2400** lists the various medical codes that may be associated with a home testing device that is used to test for a streptococcal infection. The table **2400** is representative of the types of codes that may be stored in the database **2304** in relation to a particular retail strep test device. The table **2400** lists a diagnosis code of J02.0, an ICD-10-CM code for streptococcal pharyngitis. The table **2400** also lists an HCPCS code of G0435, which is a code for a rapid antibody test. The table **2400** also lists an NDC code of 54569-5182-0, which is the NDC code for an amoxicillin prescription. Thus, when the server **2306** assigns the medical codes to the testing device or the test results, various codes may be produced. The example shown in table **2400** shows that the strep home retail testing device is assigned the HCPCS code of G0435 to indicate the type of test it is, a rapid antibody test. If the test results come back as positive, the server assigns the ICD-10-CM code to this event, indicating a streptococcal throat infection. In response to these positive test results, the server **2306** provides the NDC code for amoxicillin as a recommended prescription to give to the user to treat the infection.

[0132] In some embodiments, this prescription may be passed to a pharmacy so that the pharmacy may fill the prescription for the user to pick up, or to be delivered to the user. In some embodiments, the medical codes and other information may be passed to a physician for review. This physician may be the primary care physician of the user, allowing the user to set an appointment to go over the test results and get a prescription from the physician. In other embodiments, the physician may be a telemedicine physician that either the user contacts, the physician sets up a telemedicine conference, or the system described herein automatically initiates in response to the test results. The physician may alter the recommended prescription provided by the system, may conduct additional testing, or otherwise handle the situation as he or she sees fit as a physician. In addition, in some embodiments, the medical codes may be passed to an insurance company to seek reimbursement for the testing device, the prescription, the visit with the physician, or any other costs that arise from this testing event. To accomplish such, the user may have provided his or her insurance information when signing up to use the mobile application in conjunction with the various testing devices provided.

[0133] Referring now to FIG. **25**, there is illustrated a combined pregnancy and Zika home retail test codes table **2500**. The table **2500** lists the various medical codes that may be associated with a home testing device that is used to test for both pregnancy and a Zika infection. The table **2500**

is representative of the types of codes that may be stored in the database **2304** in relation to a particular retail pregnancy/Zika testing device. The table **2500** has a pregnancy codes column and a Zika codes column. The pregnancy codes column lists a diagnosis code of Z33.1, an ICD-10-CM code for a pregnant state. The pregnancy codes column also lists an HCPCS code of G8802, which is a code for a pregnancy test. The pregnancy codes column also lists an NDC code of 42192-321-30, which is the NDC code for prenatal vitamins. The Zika codes column lists a diagnosis code of A92.5, an ICD-10-CM code for the Zika virus. The Zika codes column also lists an HCPCS code of G0435, which is a code for a rapid antibody test. The Zika codes column also lists an NDC code of 50580-501-30, which is the NDC code for prescription strength Tylenol. In some embodiments, instead of separate codes for each type of test performed, there may be a single code assigned to, for example, a combined pregnancy and Zika test, or even a single code for a pregnant with Zika infection state.

[0134] It will be understood that the codes listed in FIGS. **24-25** are examples of how the system may assign codes to a testing event. The use of the specific codes and the types of codes (ICD-10-CM, HCPCS, and NDC codes) are merely used for illustrative purposes; any type of codes may be used and the specific codes listed in FIGS. **24-25** may be other, more appropriate, codes for the particular testing device, diagnosis, etc. Different types of codes include, but are not limited to, ICD-9-CM, ICPC-2, NANDA, Read code, SNOMED, CCI, CDT, NIC, NMDS, NOC, CCAM, OPCS-4, or other codes.

[0135] Referring now to FIG. **26**, there is illustrated a flowchart of one embodiment of a medical code correlation process **2600**. The process begins at step **2602** where the mobile device **2302** running the application described herein transmits a diagnostic test identifier to the remote server **2306**. At step **2604**, the remote server **2306** correlates the diagnostic test identifier with a medical code associated with the particular diagnostic test. This identifier allows for the type of test being used by the user of the mobile device **2302** to be determined. The identifier may simply be the name of the test, may be a number associated with the test, or any other means of identifying the test being performed by the user of the mobile device **2302**. This may be done when the phone capture the image of the testing device to process the results, or the user may enter the test to be performed before a test is conducted, at which time the mobile device **2302** may pass the identifier to the remote server. In other embodiments, the diagnostic test identifier may even be the medical code. For example, if the diagnostic test is a strep test, the identifier may be G0435, an HCPCS code for a rapid immunoassay test, or any other appropriate medical code.

[0136] The process then flows to step **2606**, where the mobile device **2302**, as part of the overall operation of the system and mobile application described herein, capture an image of the testing device for processing. At step **2608**, the image is processed to achieve the test results. Such processing may be performed on the mobile device **2302**, on the remote server **2306**, another server, or any other device that may be interfaced with the system disclosed herein. The process then flows to decision block **2610**, where it is determined whether the test results indicated a positive result (positive infection, pregnancy, or other outcomes). If the test result is positive, the process flows to step **2612**, where the remote server **2306** correlates a medical code with the test results. As described herein, components other than the remote server **2306** may correlate the test results with a medical code, such as a centralized server and database used in the healthcare industry to retrieve medical codes. The process then flows to step **2614** to assign a recommended pharmaceutical product based on the test results. This may be an NDC code for a product, and there may even be provided a prescription for such. At step **2616**, the codes are transmitted to the appropriate healthcare entities, such as a physician, a pharmacy, or other entities.

[0137] If at decision block **2610** it is determined that the test results are negative, the process instead flows to step **2618**, where no medical code is correlated with the test results. This provides that no diagnosis code if provided, since the test results indicate that the user is not positive for the condition being tested. However, a medical code for the test itself, determined at step **2604**, may still be applicable in this scenario, because the user still used the diagnostic test, and therefore may still be reimbursed for the cost of the test, if the user's insurance company chooses to do so. The user's physician may also want to see the test results, even if they are negative, and the code for the test and the negative results may still be transmitted to the physician. Therefore, after step **2618**, the process then flows to step **2616** to transmit the codes (in this case, the code for the testing device product) to the appropriate healthcare entities. The test results themselves may also be transmitted.

[0138] Referring now to FIG. **27**, there is illustrated one embodiment of a telemedicine initiation option within a mobile application. The mobile application and system described herein is predominantly meant to first test a patient for a medical condition, and then recommend an action, such as seeing a physician. However, the system allows for telemedicine conferences to be initiated, and therefore functionality may exist wherein a user can request a telemedicine conference with a physician at any time while using the mobile application, in order to receive a diagnosis or simply to ask questions. Thus, FIG. **27** again shows the plurality of test functions **2102** displayed on the screen **804**. In addition to these options, an additional option is presented to the user. This option is a telemedicine conference button **2702** that allows a user to initiate a telemedicine conference with a qualified telemedicine provider. This button **2702** is shown on the screen where the user selects the type of test to be performed, but the button **2702** may be presented within the user interface on any screen of the mobile application.

[0139] Referring now to FIG. **28**, there is illustrated another embodiment of a telemedicine initiation option within a mobile application. There is shown on the screen **804** the test results as previously shown on FIG. **22**, which indicate positive pregnancy and Zika test results. In such a situation where the test results indicate a possible serious medical condition, a button **2802** may appear to the user on the screen **804**. The button **2802** may have a warning message within, urging the user to seek a consultation with a physician to talk about the user's options in light of the positive test results, and inviting the user to tap the button **2802** to initiate a telemedicine conference with a physician. Tapping the button **2802** will initiate such a telemedicine conference. The physician that is connected with for the conference may be an on-call physician that has agreed to make his or her services available through the system described herein, the telemedicine conference may use an existed telemedicine conference platform and physician

base, the user's primary care physician may be a user of the system and mobile application, allowing for them to be used as the default telemedicine contact for the user, or other methods of making physicians available for a conference with the users of the mobile application may be provided.

[0140] Referring now to FIG. **29**, there is illustrated one embodiment of a telemedicine conference session on a mobile device. During a telemedicine conference that has been initiated as described herein, the user is presented with a video conference window **2902** on the screen **804**. The video conference window **2902** allows for user to see the physician that is providing the telemedicine services to the user. It will be understood that the physician may have a similar video window on the device being used by the physician that allows the physician to see the user. This allows the physician to make some visual observations of the user's condition. In addition to the video conference window **2902**, the user is presented with a plurality of actions **2904** on the screen **804**. The plurality of action **2904** may be buttons that allow the user to provide the physician with further information. For example, one button may allow for the user to send a photograph to the physician, such as a photograph of the user's symptoms, or of the user's test results presented on the testing device. One button may also provide an option for sending the user's medical file to the physician, so that the physician can review the user's medical history or other important information. This medical file may include all the information accumulated from all tests performed by the user under the system described herein, and may also include all other medical history information. The user may have provided a copy of his or her medical history, or such may have been retrieved from a central electronic medical records system.

[0141] Other actions that may be provided in the plurality of actions **2904** may be a button to send test results to the physician. This would allow the user to send the test results of the latest test the user took before initiating the telemedicine conference, or it may allow for the user to choose the test. The plurality of actions **2904** may also include a button for sending the user's insurance information to the physician. The user may have provided this information within the mobile application and had it stored to the server, or this information may have been pulled via a confidential link from a centralized database for the user based on the user's identification information. This option allows the user to give the physician insurance information so that the physician can use the user's insurance for reimbursement of the telemedicine services, and may even set up reimbursement to the user for certain services or products, such as the testing device used for the test.

[0142] Referring now to FIG. **30**, there is illustrated a flowchart of one embodiment of a medical file handoff process **3000**. The process **3000** starts at step **3002** where a user is provided with diagnostic test results at the conclusion of a performance of a test. At decision block **3004**, it is determined whether the test results provide a positive result. If not, at step **3006** the results are stored on the server of the system described herein and the process ends at end block **3016**. If the results are positive, the process flows to step **3008** where the results are stored on the server. At step **3010**, it is determined whether a telemedicine conference has been initiated. This initiation may have been selected as described with respect to FIGS. **27** and **28**, may have been initiated automatically due to the results provided, or may have been initiated in some other way. If the telemedicine conference was not initiated, the process ends at end block **3016**. If the telemedicine conference was initiated, the process flows to step **3012** where the test results are passed to the telemedicine provider participating in the telemedicine conference. The process then flows to step **3014**, where other user information is passed to the telemedicine provider. The process then ends at end block **3016**.

[0143] The passing of the results to the telemedicine provider and other information at steps **3012** and **3014** may be performed by the user's mobile device, wherein the mobile device sends the files to the telemedicine provider. The passing may also be done by the server of the system described herein, wherein the results and other information were previously stored to the server and the server then passes the results and other information to the telemedicine provider as a result of the server being notified of a telemedicine conference initiation. The other user information of step **3014** may be any information needed by the telemedicine provider, such as past medical records and medical history of the user, past test results, insurance information, or any other information.

[0144] Referring now to FIG. **31**, there is illustrated a flowchart of one embodiment of a telemedicine conference initiation process **3100**. The process **3100** starts at step **3102** where a user is provided with diagnostic test results at the conclusion of a performance of a test. At decision block **3104**, it is determined whether the test results provide a positive result. If not, at step **3106** the results are stored on the server of the system described herein and the process ends at end block **3118**. If the results are positive, the process flows to step **3108** where the results are stored on the server. At step **3110** a telemedicine button is presented to the user on the screen of the mobile device, similar to that shown in FIG. **28**. This button recommends to the user that the user initiate a telemedicine conference, since the test results indicate a positive reaction. At step **3112**, it is determined whether a telemedicine conference has been initiated. This initiation may have been selected as described with respect to FIGS. **27** and **28**, may have been initiated automatically due to the results provided, or may have been initiated in some other way. If the telemedicine conference was not initiated, the process ends at end block **3118**. If the telemedicine conference was initiated, the process flows to step **3114** where the test results are passed to the telemedicine provider participating in the telemedicine conference. The process then flows to step **3116**, where other user information is passed to the telemedicine provider. The process then ends at end block **3118**.

[0145] The passing of the results to the telemedicine provider and other information at steps **3114** and **3116** may be performed by the user's mobile device, wherein the mobile device sends the files to the telemedicine provider. The passing may also be done by the server of the system described herein, wherein the results and other information was previously stored to the server and the server then passes the results and other information to the telemedicine provider as a result of the server being notified of a telemedicine conference initiation. The other user information of step **3116** may be any information needed by the telemedicine provider, such as past medical records and history of the user, past test results, insurance information, or any other information.

[0146] Turning now to FIG. **32**A, there is illustrated an embodiment of a system in which a prescription is transmitted to a pharmacy using a self-diagnostic test and telemedicine. In these embodiments, rather than the patient needing to physically travel to a pharmacy to drop off a prescription to be filled, the user uses a mobile application to electronically transmit the prescription information to the pharmacy. These embodiments improve upon embodiments which use self-diagnostic tests and telemedicine and take advantage of the fact that the user is already engaged in a telemedicine session with the user's healthcare provider through a network **3202** such as the internet. In these embodiments, the user engages in a telemedicine session with a healthcare provider as described hereinabove, via Path ①. When the user and the healthcare provider complete the telemedicine session, the healthcare provider can prescribe necessary medicine to the mobile application user. However, since the user is not physically present with the healthcare provider, the user does not pick up a physical prescription slip. Instead, the healthcare provider transmits via Path ② the prescription in electronic form either to the user's mobile application, or to the pharmacy of the user's choice. If the healthcare provider transmits the "electronic prescription" to the user's mobile application, then the user can then store the electronic prescription on his mobile device **802** in the mobile application until he is ready to get the prescription filled. The user then uses the mobile application to send the electronic prescription to the pharmacy via Path ③. The pharmacy then fills the prescription as normal.

[0147] Turning now to FIG. **32**B, there is illustrated another embodiment of a system in which a prescription is transmitted to a pharmacy using a self-diagnostic test and telemedicine. These embodiments are similar to those described hereinabove with respect to FIG. **32**A. The system includes a user with a mobile device **802** running a mobile application, a healthcare provider, a pharmacy, and a remote server or central office with a records database. In these embodiments, the user participates in a telemedicine session with a healthcare provider via Path ① as described hereinabove with respect to FIGS. **29-31**. Next, if the healthcare provider decides that a prescription is needed, the healthcare provider creates a prescription record and transmits the record through a network **3202** such as the internet to a central office **3204** or remote server via Path ②. The central office **3204** then stores the record in a records database **3206**. When the user is ready to have their prescription filled, they use the mobile application on the mobile device **802** to contact the central office **3204** via Path ③. The central office **3204** then retrieves the prescription record from the database **3206** and sends the prescription record to the pharmacy via Path ④ to have the prescription filled. With this method, the healthcare provider does not have to worry about which pharmacy to send the prescription to, and the fact that the prescription record does not have to be stored on the mobile device **802** means that the user could potentially access the prescription record from another mobile device or any other compatible device with network access.

[0148] Turning now to FIG. **33**, there is illustrated an embodiment in which the mobile application running on the mobile device **802** displays what prescriptions have been prescribed by the healthcare provider to the user. In these embodiments, the mobile application informs the user what prescriptions have been issued or "written" for him by the healthcare provider without the need of physical records. The user receives a notification from the mobile application when the healthcare provider has given the prescription. For example, if the healthcare provider issues ("writes") the prescription during the telemedicine session, the screen illustrated in FIG. **33** will be presented at that time. Or, if the healthcare provider writes the prescription after the telemedicine session has ended, the user will be notified by the mobile application at that time.

[0149] Turning now to FIG. **34**, there is illustrated a mobile device **802** from an embodiment in which the user can select which pharmacy to send the prescription to. In these embodiments, a menu displays a choice of pharmacies. These choices can be based on geographic location, on which pharmacies accept the user's insurance, or any other factor which might influence a user's choice of pharmacy. Once the user selects which pharmacy will fill the prescription, the prescription record is transmitted to that pharmacy so that it can be filled. In some embodiments, a preferred pharmacy is selected ahead of time, so that the user does not have to select a pharmacy each time the user receives a prescription from a healthcare provider. In these embodiments, the user is presented instead with a confirmation screen which user will use to send the prescription to the previously-chosen pharmacy to be filled.

[0150] Turning now to FIG. **35**, there is illustrated a mobile device **802** from an embodiment of the system which allows for the prescription to either be picked up or delivered. In some embodiments of the system, the user is offered the convenience of having the prescription delivered to the user's home or place of work. In these embodiments, when a prescription is sent to a pharmacy to be filled, the user is presented with a menu in the mobile application which gives him the option of choosing to pick up the prescription himself, or of having the prescription delivered. If the user selects to have the prescription delivered, the user will then be presented with a screen in the mobile application where he or she enters the delivery address. Some embodiments will allow for addresses to be pre-entered into the mobile application and saved. This will speed up future prescription fillings, as the user will not have to enter the delivery address every time he selects to have a prescription delivered. In some embodiments, if the user selects to pick up the prescription, the user will be given an estimated ready time for the prescription or a notification through the mobile application when the prescription is ready to be picked up.

[0151] Turning now to FIG. **36**, there is illustrated a flowchart of the process for using a self-diagnostic test and telemedicine to obtain a prescription. The process starts at Start block **3602** and proceeds to block **3604**. At block **3604**, the user performs a self-diagnostic test such as is described hereinabove with respect to FIGS. **9** and **11**. Next, at block **3606**, a telemedicine session is established and occurs between the user and a healthcare provider as described hereinabove with respect to FIGS. **29-31**. Next, the process moves to block **3608**, where the healthcare provider determines that the user needs a prescription. In some embodiments, this step takes place during the telemedicine session. Next, the process moves to block **3610**, where the healthcare provider issues a prescription for the user and enters the prescription information into the telemedicine system. Next, at block **3612**, the user is notified through the mobile application that they have been prescribed medication. The process then moves to block **3614**, where the user selects a pharmacy to fill the prescription. As discussed hereinabove

with respect to FIG. **34**, this step may not take place if the user has a pharmacy pre-selected. Next, at block **3616**, the mobile application causes the prescription to be sent to the pharmacy to be filled. The process then moves to block **3618**, where the pharmacy fills the prescription. The block then moves to decision block **3620**, where the user chooses whether the prescription will be picked up or delivered. If the user chooses to pick up the prescription, the process moves to function block **3622**, where the system sends the user a notification that the prescription is ready for pick-up. The process moves to block **3624**, where the user picks up the prescription and then ends at block **3626**. If the user chooses to have the prescription delivered, then the process moves to block **3628**, where the prescription is delivered to the user at his selected address. The process then ends at block **3626**.

[0152] Turning now to FIG. **37**, there is illustrated an embodiment in which a telemedicine mobile application is used to automatically fill a prescription. In some cases, when a patient is diagnosed with a particular ailment, the prescription is likely to be a predetermined medication or set of medications. In these cases, a healthcare provider can often issue a prescription for the user without having to actually see or talk to the user. Having a user's health history and the results of a diagnostic test are often enough for a healthcare provider to issue a prescription for a user. Some embodiments take advantage of these situations and improve the efficiency of the telemedicine and prescription-filling process by allowing prescriptions to be issued and filled automatically, without significant interaction between the user and the healthcare provider. The process starts at Start block **3702** and proceeds to function block **3704**, where the user performs a self-diagnostic test. The process then moves to decision block **3706**. If the self-diagnostic test returns negative results, the process loops back to block **3704** until the user performs another self-diagnostic test sometime in the future. If the test results are positive, the process moves to decision block **3708**. If the positive result from the test does not indicate a "critical" or urgent situation, the process movies to block **3710**, where a normal telemedicine proceeding occurs, as described hereinabove with respect to FIGS. **27-31**. If, however, the results indicate an urgent or critical situation which can be resolved without significant user interaction with a healthcare provider, the process moves to function block **3712**. At block **3712**, the mobile application transmits the self-diagnostic test results to a central office or remote server for the telemedicine system. The process moves to block **3714**, where a healthcare provider is assigned to the user's test results, which are transmitted by the central office to the healthcare provider. The process then moves to decision block **3716**, where, if the user has pre-registered, that is, has supplied their health history and pharmacy preferences to the telemedicine system, the process moves to block **3722**, where the healthcare provider compares the user's health history with the self-diagnostic test results to determine if a prescription should (can) be issued to the user.

[0153] If, at block **3716**, the user has not pre-registered, the process moves to block **3718**, where a session of the telemedicine application is opened on the user's mobile device. This session is simply for the user to provide the information necessary for the healthcare provider to issue the proper prescription. The process moves to block **3720**, where the user provides their health history and their pharmacy preferences to the telemedicine system through the mobile application. Next, the process move to block **3722**, where the healthcare provider compares the user's health history and the test results to determine if a prescription should be issued. The process then moves to block **3724**, where the healthcare provider issues a prescription and sends it to the pharmacy. The process moves next to block **3726**, where the telemedicine application opens on the user's mobile device. At block **3728**, the telemedicine mobile application informs the user that the prescription has been filled by the pharmacy and is ready for pick-up or delivery. The process then ends at End block **3730**.

[0154] Turning now to FIG. **38**, there is illustrated a mobile device **802** from an embodiment of the system in which the user obtains a real-time health insurance quote in response to a self-diagnostic test. These embodiments allow users to obtain health insurance quotes from multiple insurance providers or for multiple different plans through the mobile application running on the mobile device **802**. Rather than having to call or research different insurance providers individually, a user can utilize the system to obtain multiple quotes from multiple providers in a relatively short period of time. This provides a significant advantage to the user by letting them compare multiple insurance plans quickly and conveniently. An information input menu **3802** is presented to the user by the mobile application. The user inputs information relevant to obtaining an insurance quote, such as age, gender, income level (to account for possible government subsidies), or other health-related information. In some embodiments, the information input menu also allows the user to input information about their current insurance, such as their current insurance provider or insurance plan number. This allows the system to provide quotes for insurance plans which provide similar benefits to the user's current plan. Once the user enters the necessary information into the information input menu **3802**, the information is transmitted to a central office, which then queries participating insurance carriers for insurance premium quotes which are then presented to the user.

[0155] In some embodiments, the query for a real-time insurance quote occurs after a user has conducted a self-diagnostic test. In these embodiments, the information transmitted to the central office by the mobile application includes what type of test the user conducted, and in some embodiments, the results of the test. This allows the insurance carriers to provide more accurate insurance quotes to the user.

[0156] In some embodiments, the real-time insurance quotes are for health insurance. In other embodiments, the quotes are for life insurance. In still other embodiments, the quotes are for disability insurance. Some embodiments provide quotes for multiple types of insurance.

[0157] Turning now to FIG. **39**, there is illustrated an embodiment of the system in which multiple insurance plans are presented through a mobile application to a user. In these embodiments, after the user submits information as described hereinabove with respect to FIG. **38**, a central office returns to the mobile device **802** quotes for one or more health insurance plans provided by the queried insurance providers. The mobile application then presents the quotes to the user in a quote menu **3902**. These quotes are based on the information supplied by the user, and in some cases, on information regarding the type or results of the test conducted by the user. The quote menu **3902** displays not

only the insurance quotes, but also basic information about the insurance quotes, such as the insurance provider or premium cost for each respective quote. In some embodiments, the quote menu **3902** includes "buttons" **3904** for each quote which the user can click. Clicking a "button" **3904** causes the mobile application to present a new screen, described herein below with respect to FIG. **40**, which gives more detailed information about the quote which the user touched.

[0158] Turning now to FIG. **40**, there is illustrated an embodiment of the system in which more detailed information regarding a health insurance quote is presented to a user. In these embodiments, when a user clicks on a button related to a particular insurance quote, as described hereinabove with respect to FIG. **39**, the mobile application presents the user with an insurance plan details screen **4002**. The insurance plan details screen **4002** presents the user with additional details about the insurance plan chosen by the user to look at. This information can include the monthly or yearly premium, any deductible, any out-of-pocket maximum, what types of services are and are not covered, any government subsidies that might be available to a user who selects that plan, or any other piece of information that would be useful to a user contemplating selecting that insurance plan. The plan details screen **4002** may also include a website or phone number where a user can obtain additional information about the plan or the insurance provider. In some embodiments, the plan details screen **4002** will also have a banner or button **4004** which the user can click to be connected with a representative from the selected insurance company who can provide more information to the user or assist the user in signing up for the insurance plan. Different embodiments will allow a user to connect to an insurance provider representative in different ways. For example, some embodiments will provide a text chat between the user and the representative. Other embodiments will provide two-way audio or video connections between the user and a representative though which the user can discuss the insurance plans or even sign up for a plan.

[0159] Turning now to FIG. **41**, there is illustrated a diagrammatic view of a system for providing real-time health insurance quotes in response to a self-diagnostic test. In these embodiments, a system includes a user **4102** using a mobile device **802** which runs a mobile application. After a user conducts a self-diagnostic test and enters any required information into the mobile application, the mobile device **802** transmits the information (which might include information about the self-diagnostic test or its results) via Path ① through a network **4104**, such as the internet, to a central office **4106**. The central office **4106** keeps a database of records which include any insurance providers participating in the real-time insurance quote system. The central office **4106** transmits the user information via Paths ② to various participating insurance providers **4108**. Each insurance provider **4108** then uses the information provided by the central office **4108** to generate a quote (or to decline generating a quote). The insurance providers **4108** the return insurance quotes to the central office **4106** via Paths ③. Finally, the central office **4106** communicates the insurance quotes via Path ④ to the mobile application running on the mobile device **802** for the user to view.

[0160] Turning now to FIG. **42**, there is illustrated a flowchart depicting a process for generating a real-time health insurance quote in response to a self-diagnostic test. The process starts at Start block **4202** and moves to function block **4204**, where the user performs a self-diagnostic test with a mobile application, such as is described hereinabove with respect to FIGS. **8-11**. Once the user has completed he self-diagnostic test, the process moves to block **4206**, where the mobile application presents the user with a menu which allows the user to enter additional information relevant to an insurance quote. The user enters any additional information requested, and the process moves to block **4208**. At block **4208**, the mobile application transmits the user information (and, in some embodiments, test-related information) to a central office through a network such as the internet and requests quotes for health insurance coverage. The process moves next to block **4210**, where the central office accesses a list of participating insurance providers who accept quote requests through the system. The process moves to block **4212**, where the central office transmits requests for quotes, along with the supplied user information, to the participating insurance providers. At block **4214**, the each participating insurance provider uses the information received from the central office to generate personalized insurance quotes for the user. In some cases, instead of generating an insurance quote, an insurance provider may determine that, based on the user information provided, it cannot provide insurance coverage to the user, and thus will not return an insurance quote. The process moves to block **4216**, where the insurance providers transmit the quotes (or a message indicating that it will not insure the user) to the central office. Next, at block **4218**. The central office transmits the received insurance quotes to the user and the mobile device **802**. Next, at block **4220**, the mobile device **802** and mobile application present the received insurance quotes to the user. In some embodiments, the process will end at block **4220**. In other embodiments, the process will move to block **4222**, where the mobile application allows the user to view details of one or more of the insurance plans quoted to the user. The user selects a quote they are interested in, and the mobile application presents details about that plan. The process then moves to block **4224**, where the mobile application presents the user with options for contacting the insurance provider offering the selected insurance plan, such as a phone number, email, or website. In some embodiments, the mobile application will offer the option of connecting the user to an insurance provider representative through the mobile application, such as through a text chat or a two-way audio or video connection. The process then ends at End block **4226**.

[0161] The images of the testing device **302** (FIG. **3**) that have been captured may be improved by processing devices using various image processing techniques in order to determine the test results indicated within the viewing windows **306**. In addition to the testing devices **302** described hereinabove other types of images may be taken of viewing windows such as those described in U.S. Provisional Patent Application No. 62/584,704, entitled ARTIFICIAL INTELLIGENCE RESPONSE SYSTEM BASED ON TESTING WITH PARALLEL/SERIAL DUAL MICROFLUIDIC CHIP, filed on Nov. 10, 2017 (Atty. Dkt. No. RIDL60-33874), which is incorporated herein by reference in its entirety. Additional types of viewing windows which may be imaged processed are described herein below.

[0162] Referring now to FIG. **43**, there is illustrated a side cross-sectional view of an RT-lamp. The RT-lamp is a Reverse Transcription Loop-mediated isothermal Amplification device, which is a technique for the amplification of

RNA. This combines the advantages of the reverse transcription with the LAMP technique. The LAMP technique is a single technique for the application of DNA. This technique is an isothermal nucleic acid application technique, in which a chain reaction is carried out at a constant temperature and does not require a thermal cycler. The target sequences are modified at a constant temperature using either two or three sets of primers and polymerase with high strand displacement activity in addition to a replication activity. The addition of the reverse transcription phase allows for the detection of RNA and provides a one-step nucleic acid amplification method that is used to diagnose infectious diseases caused by bacteria or viruses.

[0163] FIG. **43** illustrates an example in which a multimode instrument **4301** is coupled to a smartphone **4302**. The smartphone **4302** includes an LED **4304** and a camera **4306**. The camera **4306** includes an image sensor, such as a CCD (charge coupled device). The instrument **4300** includes a sample chamber **4308** for receiving an optical assay medium. The optical assay medium comprises the labeled biologic sample disposed within the viewing window on the microfluidic chip. The sample chamber **4308** may include a door **4310** that prevents stray light from entering.

[0164] The optical assay medium is positioned over a detection head **4312** in the sample chamber **4308**. The instrument **4300** includes an optical output path for receiving an optical output from the optical assay medium in the sample chamber **4308** via the detection head **4312**. The optical output path may include a multimode fiber **4314** that directs light from the detection head **4312** to a cylindrical lens **4316**. The optical output path may further include a wavelength-dispersive element, such as a diffraction grating **4318**, that is configured to disperse the optical output into spatially-separated wavelength components. The optical output path may also include other optical components, such as collimating lenses, filters, and polarizers.

[0165] The instrument **4301** can include a mount for removably mounting the smartphone **4302** in a working position such that the camera **4306** is optically coupled to the optical path, for example, in a predetermined position relative to the diffraction grating **4318**. In this working position, the camera **4306** can receive at least a portion of the dispersed optical output such that different locations are received at different locations on the image sensor.

[0166] The instrument **4301** may also include an input optical path for directing light from a light source to the optical assay medium in the sample chamber **4308**, for example, through the detection head **4312**. In some instances, the LED **4304** on the smartphone **4302** could be used as the light source. To use the LED **4304** as the light source, the input optical path may include a collimating lens **4320** that receives light from the LED **4304** when the smartphone **4302** is mounted to the instrument **4300** in the working position. The input optical path may further include a multimode fiber **4322** that directs the light from the collimating lens **4320** to the detection head **4312**. The input optical path may also include other optical components, such as collimating lenses, filters, and polarizers.

[0167] The instrument **4300** may also include an additional input optical path that directs light form an internal light source, such as a laser **4324**, to the optical assay medium in the sample chamber **4308**. The additional input optical path may include a multimode optical fiber **4326**, as well as collimating lenses, filters, polarizers, or other optical components.

[0168] Referring now to FIG. **44**, there is illustrated the view of the RT-lamp **4301** with a microfluidics chip **4402** disposed within the sample chamber **4308**.

[0169] Referring now to FIG. **45**, there is illustrated a side view of the smart phone **4302** interfaced with the microfluidic chip **4402** for imaging the surface thereof, which is illustrated in a window view in FIG. **46**. This window view illustrates the viewing window as a box **4602** in which the image of the microfluidic chip **4402** is displayed. The application automatically recognizes various markers **4604**, **4606** and **4608** on three corners thereof. This will allow orientation of the window with respect to the application. A box **4610** in phantom dashes will be oriented by the application running on the smart phone **4302**. Once the box has been oriented visually about the image of the microfluidic chip **4402**, then processing can proceed. The processing is basically focusing upon the chip to gain the best optical image of the target sites. The target sites are storage reservoirs **4612** and **4630**, for example. Each of these will have a viewing well **4618** associated therewith, and these viewing wells **4618** will have, in one example, a process biologic sample having affinity labels associated there with that fluoresce. By recognizing the florescence, the presence of the cell can be determined. The lack of florescence indicates that the cell, a bacterium for example, has been destroyed. This can be a positive test. By examining at each stage of the testing process the chip, a determination can be made as to results in essentially real time. This will be described in more detail herein below. Once the image is believed to be in focus, the user can actually take the picture or the application cell can automatically determine that the focus is adequate and take that. This is very similar to character recognition techniques that are utilized in recognizing faces in camera images received by the phone.

[0170] FIG. **47** illustrates a diagrammatic view of a biofluidic analysis system **4700** in accordance with various embodiments of the present disclosure. The system **4700** may include a mobile device **4702**. The mobile device **4702** may be a mobile handheld user device, such as a smart phone, tablet, or the like. The mobile device **4702** may include a processor **4704**, a memory **4706**, an input/output (I/O) interface **4708**, a display **4710**, and a communication interface **4712** all connected via a bus **4714**. The communication interface may connect the mobile device **4702** to outside sources, such as a server **4716** having a database **4718** associated therewith, over a network **4720**, i.e. a cellular network or Internet network. The memory **4706** may store an operating system **4722** and various special-purpose applications, such as a browser by which webpages and advertisements are presented, or special-purpose native applications, such as weather applications, games, social-networking applications, shopping applications, and the like. The digital data package may provide data to a special purpose native application **4724** stored in the memory **4706**, the application **4724** having associated therewith an application programming interface (API) **4726**. The digital data package may be obtained by the mobile device **4702** by a test results capture module **4728** connected to the processor **4704**. The test results capture module **4728** may capture an image, scan, video, or other digital media of a testing device **4730**, converting the analog biologic sample testing device

and the results presented on the device to a digital format and to create a unique identifier that can be used to trigger a plurality of events. The test results capture module **4730** (or an associated module) may also perform image processing on the captured image so that the test results may be better analyzed.

[0171] The unique identifier comprising the digital data package may be analyzed by the application **4724** to determine the results from the analog testing device. In some embodiments, the determination of the test results, due to the type of analog testing device, is not determined locally by the application **4724**. In some embodiments, the unique identifier may be transmitted to the server **4716**, via the network **4720**, for remote analysis of the data contained in the unique identifier. In some cases, results from the analog testing device may be determined locally and remotely. In some instances, the user of the mobile device **4702** may not have cellular network or Internet connection, for instance, the settings for connectivity on the mobile device **4702** is disabled, turned off or a combination thereof. In this case, the transmission of the unique identifier to the server **4716** may be postponed until a connection is available.

[0172] In some embodiments, the mobile device **4702** may include a location sensor, such as a global positioning system (GPS) sensor or other components by which geographic location is obtained, for instance, based on the current wireless environment of the mobile device **4702**, like SSIDs of nearby wireless base stations, or identifiers of cellular towers in range. In some cases, geographic locations are inferred by, for instance, an IP address through which a given mobile device **4702** communicates via the Internet, which may be a less accurate measure than GPS-determined locations. In other cases, geographic location is determined based on a cell tower to which a mobile device **4702** is wirelessly connected. Depending on how the geographic data is acquired and subsequently processed, that data may have better or less reliable quality and accuracy.

[0173] FIG. **48** illustrates a diagrammatic view of an analog testing device to a digital format and unique identifier conversion process **4800** in accordance with various embodiments of the present disclosure. A testing device **4802** may provide medical test results in an analog format, such as in a results display window **4804** indicating a positive or negative sign, a color spectrum, a line, a circle, a curve, a balloon, a signature marker, or variance of the like. A biologic specimen may be deposited into the testing device **4802** where the biologic may bind or react with particular reagents specific to the type of test to which the testing device **4802** pertains. The testing device **4802** may also include a test type identifier **4806**, such as a code, graphic, symbol, or other indicator on a surface of the testing device **4802**.

[0174] A mobile device **4808**, which may be the mobile device **4702** described herein, may include a capture device **4810**. The mobile device **4808** may convert use the capture device **4810**, in addition to other data known or otherwise obtained by the mobile device **4808**, to convert the analog data and biologic presented by the testing device **4802** to a digital unique identifier. When digital media such as an image, video, or other digital format of the testing device **4802** is captured by the capture device **4810**, certain properties may be analyzed, processed, and stored into as a digital data package. For instance, the test type associated with the testing device **4802** may be determined by the mobile device **4808** by identifying the particular test associated with the test type identifier **4806** captured within the digital media.

[0175] Test results provided in the results display window **4804** or elsewhere on the testing device **4802** may also be captured within the digital media and analyzed. For example, in the case of a color indicator as the result of the test, the RGB values of the pixels contained in the digital media of the test results may be determined in order to provide a digital value for the test results. The test result may be stored in the digital data package in a particular digital format, for instance, a positive or negative test result value. The value may be a binary value, a rating, a probability, or other type of result indicator. The biologic specimen used to conduct the test may also be included in the digital data package. The biologic specimen provided into the testing device **4802** may be determined from the test type identifier **4806**, since in many cases the specific test will dictate the biologic to be used.

[0176] The data provided by the digital data package may also include the type, manufacture and serial number of the testing device **4802**, and a timestamp for when the capture device **4810** captured the digital media. The manufacture, serial number and cellular provider of the mobile device **4808** may also be included in the digital data package. The application **4724** may then generate the unique identifier **4812** from the data of the testing device **4802** and mobile device **4808**, in combination with data of the user of the mobile device **4808**. Data of the user may be the user's name, birthday, age, gender, social security number, height, weight, race, diagnosis status, insurance information, medical codes, drug codes, and the like, and a combination thereof.

[0177] In some embodiments, the unique identifier may be verified by a verification server, such as the server **4716**, to determine the authentication of the biological specimen. In some cases, the user may provide the analog testing device **4802** with a substance not classified as a biological specimen. In this instance, an application on the server **4716** will provide the application program **4724** with a message indicating an error, in which the user may be required to provide a biological specimen to a different analog testing device. In some embodiments, after verification of a biological specimen, the local application program **4724** or the server **4716** via the user's application program **4724** will provide the user with a positive or negative outcome of the analog testing device **4802**. In some cases, the user is displayed a negative test result and the application program **4724** of the mobile device **4808** indicates that testing is completed. In other cases, the user is displayed a positive test result by the application program **4724** on the display **3110** of the mobile device **4808**.

[0178] The unique identifier **4812** may include a plurality of digital data streams **4814** used during creation of the unique identifier **4812**, such as information included within the digital data package, or otherwise known or obtained by the mobile device **4808** or the server **4716**. The plurality of digital data streams **4814** (D1, D2, D3, D4 . . . Dn) may be assembled together to create the unique identifier **4812**, and the mobile device **4808**, the server **4716**, or the authorized system components may parse or deconstruct the unique identifier **4812** to analyze specific user properties or test properties, and to trigger events based on the properties.

[0179] Creating a single unique identifier **4812** which contains many different items of information is an efficient way of associating many different types of information with a single biologic, user, test, etc. Every time a test is conducted, a new unique identifier **4812** may be created. Each unique identifier created may include the plurality of data streams **4814**. Each one of the plurality of data streams **4814** in the unique identifier **4812** stores a different type of information. In some embodiments, the information stored in data streams **4814** includes the test type, the test results, demographics of the user, or an identification number, such as an IMSI number, for the mobile device **4808**. In some embodiments, the unique identifier **4812** is set up in a structural format, such that each data stream **4814** is a subcomponent of the unique identifier **4812**. In some embodiments, unique identifier **4812** is a string of alphanumeric characters, and the data streams **4814** which make up the unique identifier **4812** are simply different portions of the character string. In these embodiments, the format of the unique identifier **4812** is known to a database or server which can correctly parse the unique identifier **4812** into the separate data streams **4814** for analysis.

[0180] Referring now to FIG. **49**, analyzing medical self-tests from a computer vision aspect typically such as those describe above involves three main steps. In real time, a determination is made at step **4902** if the test device is in the picture. A medical self-test would comprise any medical test executed by an individual that was not executed in a lab or professional environment. For example, but not limited to, a person performing a flu test on themselves or a family member. If the test device is located in the picture, a photo of the test device is automatically taken at step **4904** (a.k.a. auto capture). If the test device is not located within the picture, the process is completed and no picture is taken. Next, the area of the test device that contains the diagnostic information (e.g., the test strip embedded in the test cassette) is identified at step **4906**. The diagnostic information (e.g., one or more test lines within the test strip window of a cassette) are read and classified at step **4908**.

[0181] The algorithms that perform these steps should be invariant to the following so-called perturbations:

[0182] Any variation in the location of the test device within the image

[0183] Any variation of the orientation of the test device

[0184] Any variation in color of the test device

[0185] Any variation in color sensitivity of the camera

[0186] Variable lighting conditions

[0187] Shadows

[0188] Glare

[0189] Dirt on the test devices

[0190] Noise

[0191] The main challenge faced when developing robust computer vision algorithms for automatically reading and classifying a medical self-test, is to design algorithms that are insensitive to the above listed perturbations.

[0192] To design computer vision algorithms resilient to the perturbations listed above, it is important to perform the image processing based on geometrical attributes of the image, rather than (color) intensity attributes. This is typically achieved by using some form of edge detection to generate a description of different features of the test device. However, traditional edge detection methods suffer from several drawbacks that make such algorithms unreliable when faced with some of the perturbations listed above. Such drawbacks include:

[0193] Sensitivity to noise, particularly under low lighting conditions.

[0194] Use of de-noising methods often tends to give poor localizations of edges.

[0195] The edge detection response does not always correspond to the geometrical fidelity of the edge, but rather to the color intensity.

[0196] Poor accuracy for detecting thin lines.

[0197] Edge detection methods tend to pick up all edges in an image, including edges that are not useful for the feature detection task (over-segmentation).

[0198] Edge detection methods by themselves are not useful for measuring the curvature of an edge.

[0199] The methods typically require a large number of parameters to be tuned for good performance.

[0200] In order to overcome these problems, a generalization of the Curve Field Transform (CFT) (a.k.a. the Curve Filter Transform) may be used. Using this method has several advantages compared to traditional (edge) segmentation methods, including:

[0201] Resilience to noise and low contrast.

[0202] The CFT response corresponds to the geometrical fidelity of the edge, rather than the color contrast of the edge.

[0203] Works well for thin features.

[0204] Can classify edges and curves according to their curvature, angle, and scale.

[0205] Only requires one basic parameter, the scale(s) of the feature(s) to be detected.

The Generalized Curve Field Transform (GCFT)

[0206] Referring now to FIG. **51**, the main ideas of the CFT (Curve Field Transform) can be summarized as follows. The bottom portion of FIG. **50** shows the orientation fields for the region in the upper right image. The darkness of each line segment indicates the reliability of the corresponding orientation. Next, compute the orientation based on integration, rather than differentiation at step **5102**. Using integration makes the method significantly more resilient to noise. The assignment of an orientation to each pixel results in an orientation field. The process of computing the orientation at step **502** includes the steps of computing the reliability weight at step **5104** such that it measures the geometrical fidelity of the underlying structure, rather than the (local) contrast of the underlying structure and computing an orientation angle at step **5106**. A notion of "backward/forward" is not associated with the line segment, as is traditionally done for gradient vectors of an image. This means that the orientation angle has a periodicity of 180 degrees rather than 360 degrees. A directed line segment (orientation) is assigned at step **5108** consisting of an angle and a reliability value based upon the computed orientation and reliability. The reliability comprises weight assigned to each pixel in the image (see FIG. **50**). Lines and curves are located at step **5110** using alignment integrals in the orientation field along which the underlying orientations align in a consistent manner as shown in FIG. **52**. The superimposed thick curve **5202** of the image illustrates a line along which the underlying orientations align with the superimposed curve.

[0207] A general set of references on the Curve Field Transform, and the related Orientation Field Transform are described in [1] Sandberg, K., Brega, M.: Segmentation of thin structures in electron micrographs using orientation Fields. J. Struct. Biol. 157, 403-415 (2007); [2] Sandberg, K.: Methods for image segmentation in cellular tomography. In: McIntosh, J. R. (ed.), Methods in Cell Biology: Cellular Electron Microscopy, vol. 79, pp. 769-798, Elsevier (2007); [3] Sandberg, K.: Curve enhancement using orientation Fields. In Bebis, G. (ed.), Advances in Visual Computing, Part I. LNCS, vol. 5875, pp. 564-575, Springer, Heidelberg (2009); [4] Sandberg, K.: The Generalized Orientation Field Transform. In R. P. Barneva, et al. (ed.), Object Modeling, Algorithms, and Applications, pp. 107-112, Research Publishing (2010); [5] Sandberg, K.: The Curve Filter Transform—a Robust Method for Curve Enhancement. In Bebis, G. (ed.), Advances in Visual Computing, Part II. LNCS, vol. 6454, pp. 107-116, Springer, Heidelberg (2010), each of which are incorporated herein by reference.

[0208] The mathematical formulation of these components may be computed as described herein below. Let I(x) denote the image intensity at location (pixel) $x \subset D$, where D denotes the image domain. For clarity, only gray scale images are considered in this presentation. The generalization to color images is straight forward by processing one or more channels of a color image separately.

[0209] The orientation field is defined as:

$$F(x)=(x),\theta(x))$$

where as shown in FIG. **53** w denotes a real-valued weight (step **5302**) and θ denotes an angle (step **5304**) in the interval [0,π). A critical property is that the angle is defined for angles in the interval [0; 180°), rather than the more traditional choice [0; 360°). This reflects the fact that the notion of a "forward" or "backward" direction for our orientation is removed. The weight should have the property that |w(x)| measures the reliability of the orientation angle θ(x) at location x.

[0210] The mathematics associated with the orientation field generation are as follows. Let $r_\varphi(x, s)$ denote a parameterized straight line of length L and angle φ centered at x such that

$$r_\varphi(x, s) = x + s\cos\varphi\hat{x} + s\sin\varphi\hat{y}, s \in \left[-\frac{L}{2}, \frac{L}{2}\right] \quad (1)$$

Here $\hat{x}$ and $\hat{y}$ denote the unit vectors in the x- and y-directions, respectively.

[0211] We define the orientation spectrum function as:

$$O(x, \varphi) = \int_{-\frac{L}{2}}^{\frac{L}{2}} I(r_\varphi(x, s))ds$$

where L is a scale parameter. This integral measures the image intensity along a straight line of angle φ, length L, centered at pixel x in the image.

[0212] The orientation field F(x) is generated by the formula:

$$\theta(x)=\arg\max_{\theta\in[0,\pi)}\int_0^\pi K(\phi,\varphi)0(x,\varphi)d\varphi$$

$$w(x)=\max_{\theta\in[0,\pi)}\int_0^\pi K(\phi,\varphi)0(x,\varphi)d\varphi \quad (2)$$

where K(ϕ, φ) is a symmetric kernel, with the property

$$K(\phi,\phi)\leq K(\phi,\varphi),\varphi\in[0,\pi)$$

[0213] Examples of useful kernels include:

$$K_\delta(\phi,\varphi)\equiv\delta(\phi-\varphi) \quad (3)$$

where δ denotes the Dirac delta function, and

$$K_{cos(\phi,\varphi)}\equiv\cos(2(\phi-\varphi)) \quad (4)$$

[0214] The Generalized Curve Field Transform may be used for more general curves. To accommodate looking for more general curves (not necessarily straight lines), a general family of curves is denoted as:

$$\{r_\lambda(x,s)\}_{\lambda\in\Lambda} \quad (5)$$

Here Λ denote a set of curve parameters (e.g., angles and curvature), while

$$s \in \left[-\frac{L}{2}, \frac{L}{2}\right]$$

is a parameterization of the curve such that $r_\lambda(x, 0)=x$. A useful class of curves is the family of all straight lines and circular arcs of varying curvature.

[0215] The main idea is to measure the alignment of an underlying orientation field and a family of curves. The alignment at a pixel x is computed by $\cos(2(\theta(x)-v_k))$, where θ(x) represents an orientation angle and v_k represents the tangent angle of a curve. This alignment measure is integrated along a family of curves, which leads to the following definition of the alignment spectrum of the orientation field F(w(x), θ(x)):

$$G[F](x, \lambda) = \int_{-\frac{L}{2}}^{\frac{L}{2}} w(r_\lambda(x, s))\cos((2(\theta(r_\lambda(x, s)) - v_\lambda(x, s)))\left\|\frac{dr_\lambda}{ds}\right\|ds \quad (6)$$

For a given curve r_λ, this function measures the net alignment of this curve and the underlying orientation field F through a pixel x (see FIG. **54**). FIG. **54** illustrates the alignment spectrum at the center pixel x_0 of a region covering the orientation field F of a straight (horizontal) line with a thickness of 6 pixels. In this example, we have that

$$G[\mathcal{F}](x_0, 0) = 15,\ G[\mathcal{F}]\left(x_0, \frac{\pi}{4}\right) = 2.2, \text{ and } G[\mathcal{F}]\left(x_0, \frac{\pi}{2}\right) = 0.$$

Note that the net alignment can also be negative, which would happen for 0=0 at a location a few pixels below the center pixel in this example.

[0216] Note that the family of curves r_λ, is in general different from the family of curves used to generate the orientation field F. The original (or primary) orientation field F is computed using the family of straight lines. The reason for this is that it is typically better to use a more local scale for the primary orientation field, such that it only looks for locally straight lines. When looking for curved lines, we can use a family of lines r_2 that uses longer curves, and also allow these curves to include lines that are not straight.

[0217] We introduce the curve parameter kernel $P_{F(x)}(y,\lambda)$ provides a rule for how to weight the contribution of a curve

labeled by λ. Note that we allow this kernel to depend on the orientation field F(x), which allows the use of non-linear kernels. Secondly, the spread kernel $S_{G[F](y,\lambda)}(x)$, is introduced which determines to which neighboring pixels to add information about the data collected along the curve labeled by λ. For clarity, we will typically drop the reference to F in the expression for S, and use the notation $S_{G(y,\lambda)}(x)$.

[0218] Given these definitions, the Generalized Curve Field Transform (GCFT) is defined as:

$$C[F,G](x)=\int_D S_{G(y,\lambda)}(x)\left(\int_D\int_\Lambda P_{F(y)}(z,\lambda)G[F](z,\lambda)dzd\lambda\right)dy \quad (7)$$

where D denotes the domain of the image. Although this expression may seem cumbersome, in many important applications, the kernels involve delta functions that simplify the final expression.

[0219] The OFT used in [1] (Sandberg, K., Brega, M.: Segmentation of thin structures in electron micrographs using orientation Fields. J. Struct. Biol. 157, 403-415 (2007)) corresponds to the following choices in equations (2) and (7):

$\Lambda = [0, \pi)$: Family of straight lines (see Equation (1)).

$$K(\phi, \varphi) = \delta(\phi - \varphi)$$

$$G[F](x, \phi) = \int_{-\frac{L}{2}}^{\frac{L}{2}} w(r_\phi(x, s))\cos(2(\theta(r_\phi(x, s)) - \phi))ds$$

$$P_{F(y)}(z, \phi) = \delta(y - z)\delta(\phi - \phi_{max}(y)),$$

where $\phi_{max}(y) = \arg\max_{\phi\in[0,\pi)} |F(y, \phi)|$

$$S_{G(y,\phi)}(x) = \delta(x - y)$$

[0220] Using these kernels in Equation (7) gives:

$$C[F, G](x) = \int_{-\frac{L}{2}}^{\frac{L}{2}} w(r_{\phi_{max}(x)}(x, s))\cos(2(\theta(r_{\phi_{max}(x)}(x, s)) - \phi_{max}(x)))ds$$

where $\phi_{max}(x)=\arg\max_{\phi\in[0,\pi)}|F(x,\phi)|$. This integral will measure the best net alignment for any angle through pixel x. For the example in FIG. **54**, the result for the center pixel would be 15.

[0221] The CFT used in [5] (Sandberg, K.: The Curve Filter Transform—a Robust Method for Curve Enhancement. In Bebis, G. (ed.), Advances in Visual Computing, Part II. LNCS, vol. 6454, pp. 107-116, Springer, Heidelberg (2010)), each of which are incorporated herein by reference corresponds to the following choices in equations (2) and (7):

[0222] Λ: Family of circular arcs of varying curvature labeled by their tangent angles $\theta\in[0,2\pi)$ and curvature $\kappa \in (0, \kappa)$ where κ is a user specified maximum curvature. For clarity in the notation, a single parameter $\lambda\equiv(\theta, \kappa)$ denotes an individual curve.

$$K(\phi, \varphi) = \cos(2(\phi - \varphi))$$

$$G[F](x, \lambda) = \int_{-\frac{L}{2}}^{\frac{L}{2}} w(r_\lambda(x, s))\cos(2(\theta(r_\lambda(x, s)) - v_\lambda(s)))\left\|\frac{dr_\lambda}{ds}\right\|ds$$

-continued

$$P_{F(y)}(z, \lambda) = \delta(y - z)\delta(\lambda - \lambda_{max}(y))$$

where $\lambda_{max}(y) = \arg\max_{(\phi,k)\in[0,2\pi)\times(0,\kappa)} |F(y, (\phi, \kappa))|$

$$S_{G(y,\lambda)}(x) = \chi_{R_{\lambda_{max}(y)}}(x)$$

where $R_{\lambda_{max}}(y)$ is a set defined as

$$R_{\lambda_{max}}(y) = \left\{z \in D \,\middle|\, \exists\, s \in \left[-\frac{L}{2}, \frac{L}{2}\right]\colon z = r_{\lambda_{max}(y)}(y, s)\right\}$$

and χ denotes the characteristic function such that

$$\chi_{R_{\lambda_{max}(y)}}(x) = \begin{cases} 1 \text{ if } x \in R_{\lambda_{max}}(y) \\ 0 \text{ if } x \notin R_{\lambda_{max}}(y) \end{cases}$$

[0223] Using these kernels gives

$$C[F, G](x) = \int_D \chi_{R_{\lambda_{max}(y)}}(x)G[F](y, \lambda_{max}(y))dy$$

where $\lambda_{max}(y) = \arg\max_{(\phi,k)\in[0,2\pi)\times(0,k)} |F(y, (\phi, \kappa))|$

[0224] The choices for the CFT can be modified to generate a slightly different curve enhancement transform. For example, if $P_{F(y)}(z,\lambda)=1$ (a constant function) is selected, a more precise enhancement of curved structures can sometimes be achieved.

[0225] If the same family of curves as for the CFT is used, but $P_{F(y)}(z,(\theta,\kappa))=\delta(\kappa)$ is selected, we effectively single out straight lines (with curvature κ=0) in the final result. If $P_{F(y)(z,(\theta,\kappa))=}\delta(\kappa-\kappa_0)$ is chosen, curves of constant curvature κ_0 are singled out.

[0226] For this example, it might seem that if we want to detect structure of a specific curvature, we should only use lines of that curvature in our curve family to begin with. However, we are better off by still using curves of all curvatures for generating the curve field, and single out specific lines by the choice $P_{F(y)}(z,(\theta,\kappa))=\delta(\kappa-\kappa_0)$. That way we ensure that we first "label" all curved lines in the image as accurately as possible with the correct curvature, and then single out the specific curves we are interested in.

[0227] In contrast, if we are looking for curves with curvature κ_0, and only use such curves in the curve family r_λ, then curves of a similar curvature, say $\kappa_1=\kappa_0+\epsilon$ will also get a fairly high response. If a curve family including curves with both curvature k_0 and $\kappa_0+\epsilon$ is used, then curves with a curvature closer to $\kappa_1=\kappa_0+\epsilon$ will get a higher response for the curve parameter k_1 and be labeled as such. Higher precision may be achieved when identifying curves of a specific curvature by using a larger family of curves. However, using a larger family of curves also comes with a performance penalty, and is therefore not always worth the effort. This illustrates the use of GCFT to selectively filter out curves of different geometry.

Test Pad Detection

[0228] The system can be implemented in a number of applications such as test pad detection, location of a test strip, locating test pads within a strip and drug cup feature extraction. These will be more described herein below.

[0229] FIG. **55** illustrates how two test pads can be located on a test strip in an image. The process consists of two steps. First the strip is located at step **5502** using a coarse scale for the entire image. Next, the boundaries of two test pads are located at step **5504** within the strip found in step **5502** using a finer scale on a smaller region of the full image. This achieves both robustness and high computational performance.

[0230] In order to locate the test strip at step **5502**, we are specifically looking for straight lines. Also, since the lines are relatively thick line and is known from the auto-capture to extend throughout a significant portion of the image, a relatively coarse scale may be used (which is specified via the parameter L that is used for the limits of integration). Note that since L is large as we are looking at coarse scale, the underlying image can be down sampled to reduce the size of the problem for increased computational efficiency.

[0231] The following kernels can be used:

$$\Lambda = [0, \pi): \text{Family of straight lines (see Equation (1)).}$$

$$K(\phi, \varphi) = \cos(2(\phi - \varphi))$$

$$G[F](x, \phi) = \int_{-\frac{L}{2}}^{\frac{L}{2}} w(r_\phi(x, s))\cos(2(\theta(r_\phi(x, s)) - \phi))ds$$

$$P_{F(y)}(z, \phi) = H_{\phi_{max}(y)}(y, z)\cos(2(\phi - \phi_{max}(y))),$$

$$\text{where } \phi_{max}(y) = \arg\max_{\phi\in[0,\pi)} |F(y, \phi)|$$

$H_\phi(x, y)$ is a kernel illustrated in FIG. **56**. The white pixels have a value 1, gray pixels have a value 0 and the black pixels have a value −1. The kernel for the other angles θ can be generated by rotating $H_\phi(x, y)$ by θ degrees. This kernel is particularly useful for identifying lines of a specific scale.

[0232] $S_{G(y,\Phi)}(x) = \chi_{R_{\phi max}(y)}(x)$ where $R_{\phi_{max}}(y)$ is a set defined as

$$R_{\lambda_{max}}(y) = \left\{ z \in D \,\middle|\, \exists\, s \in \left[-\frac{L}{2}, \frac{L}{2}\right] : z = r_{\phi_{max}(y)}(y, s) \right\}$$

and χ denotes the characteristic function such that

$$\chi_{R_{\phi_{max}(y)}}(x) = \begin{cases} 1 \text{ if } x \in R_{\phi_{max}}(y) \\ 0 \text{ if } x \notin R_{\phi_{max}}(y) \end{cases}$$

[0233] In this application, the occurrence of many curved lines is not anticipated, and for performance reasons only a family of straight lines is used.

[0234] The choice of kernel for P leads to an interesting and useful property such that lines with a thickness that match the scale of the kernel will give a strong response, and can be shown to be stronger than the maximum response that can be obtained for a step edge. This is illustrated in FIG. **57** where the strip line has a stronger amplitude than the otherwise well-defined step edges in other parts of the image. FIG. **57** shows the output of the GCFT using a coarse scale for locating the UTI strip in FIG. **50**. The horizontal centerline **5702** indicates the location and angle of the UTI strip.

[0235] Once the strip has been identified at step **5502**, The GCFT is used at step **5504** to locate straight lines of a finer scale. FIG. **58** illustrates an example of the result. FIG. **58** shows the output of GCFT applied to the image in FIG. **50**. Despite the week edge between the test pad and the background, the GCFT is able to enhance the edges without enhancing stray edges from the background. Stray edges are otherwise a common problem with traditional edge detection methods when applied to images with low contrast edges.

Drug Cup Feature Extraction

[0236] In order to identify the strip windows on a drug cup under a wide variety of lighting conditions, some prominent coarse line features of the drug cup using the GCFT must first be identified. By analyzing the mutual distances and angles between different lines, we can determine which two lines that correspond to the stickers above and below the test strip region (see FIG. **59**). FIG. **59** illustrates the two lines that match the signature of the two stickers above and below the strip region. Once the strip region has been identified, the edges within the strip region are enhanced, as illustrated in FIG. **60**. In addition to identifying the lines, the GCFT also allows the classification of the edges by their orientations, which are illustrated by marking edge points as black (horizontal lines **6002**) and white (vertical lines **6004**) in FIG. **60**.

[0237] While the above discussion has more generally described the image analysis process, alternative embodiments and processes are described below. Referring now to FIG. **61**, there is generally illustrated the process for improving analysis of the testing results described hereinabove when an image representation of the test results is created and then analysis of the results must be carried out in order to determine what the test results are indicating. The test result image **6102** that has been digitally created from a view of the test results in some manner is provided to an image processing system **6104**. The image processing system **6104** receives the test results image **6104** and processes the image in order to create a clearer more easily analyzed image of the test results. A test results analysis **6108** may be provided that provides a diagnosis of the patient.

[0238] Referring now to FIG. **62**, there is provided a more detailed flow diagram of the image processing performed by the image processing system **6104** of FIG. **61**. Initially, the test is performed at step **6202** on the testing item which may comprise a testing device, microfluidic cassette, or any other type of device that may visually display test results. Next, an image of the test results is generated at step **6204**. The generation of the image of test results may be accomplished using for example a smart phone, a dedicated image capture system, or any other or device capable of generating a digital image of the test results as described herein that may be captured and forwarded for further processing. The generated image of the digital test results from step **6204** are input at step **6206** to the image processing system **6104** for improvement and clarification of the image. The input image data is processed at step **6208** to remove noise and other distortions from the digital image. A comparative analysis is performed at step **6210** of the process digital image. The

particular test results are determined at step **6212** based upon the processed image test data. These results are output for action at step **6214**.

[0239] Referring now to FIG. **63**, there is provided a flow diagram giving a detailed illustration of the image processing of the image of the digital test results in order to remove noise and other distortions from the generated image. A user conducted self-test is performed at step **6302** using a test device. The test device may comprise a microfluidic cassette, test strip or other type of testing device as disclosed herein above. The test results are captured at step **6304** with a digital image to provide a captured view of the test results. The generated test results are bound at step **6306** with a trackable ID that is associated with the particular test results. The type of testing device, i.e. microfluidic cassette, test strip, etc., is recognized at step **6308**, and the recognized testing device is also bound with the trackable ID at step **6310**. The first step involves the assigning of an angle to each pixel of the image of the test results at step **6312**.

[0240] The establishment of the angle of step **6312** is more particularly illustrated in the flow diagram in FIG. **64**. First a pixel is selected for testing at step **6402**. A first line is established at step **6404** for the selected pixel that has a particular orientation. An intensity response of the established line is measured at step **6406**. Once the intensity measurements for the previous line have been made at step **6406**, inquiry step **6408** determines if there is a further line possible for the selected pixel. If so, a next line is established at step **6410** and control passes back to step **6406** to measure the intensity response of the next line. This process continues until an intensity response for each possible line associated with the pixel is determined. When inquiry step **6408** determines that another line is not available, control passes to step **6412** to determine the response for each of the measured lines. The line is selected using the process described with respect to equation (2) described herein above as the orientation line for the current pixel at step **6414**. The process used in steps **6412** and **6414** would use in one example select a line having the highest intensity response. Inquiry step **6416** determines if further pixels exist within the image, and if so, control passes back to step **6402** for the next pixel. If inquiry step **6416** determines no further image pixels are available, the process is completed at step **6418**.

[0241] Referring now back to FIG. **63**, once the images been completely transformed and assigned orientation at step **6316**, the relevant geometric shapes which need to be located for within the image, are selected at step **6318**. The alignment spectrum image is created at step **6322**. the image may be filtered at step **6324** using the generalized curve field transform to remove undesired shapes and edge signatures from the image using any number of available techniques. These shapes and edge signatures may be selected to be consistent with things such as shadows, smudges, glare, etc. that interfere with the actual image of the test results that is trying to be analyzed. The filtering process is more fully described with respect to FIG. **65**. The generated alignment spectrum image is received at step **6502**. The various geometric shapes/items to be filtered from the alignment spectrum image are input at step **6504** so that they may be subtracted/removed/filtered from the alignment spectrum image. The geometric shapes are located and subtracted from the alignment spectrum image at step **6506**.

[0242] Referring now back to FIG. **63**, once the undesired features have been filtered from the alignment spectrum image at step **6324**, the relevant geometric features are identified at step **6326**. This may comprise information such as lines or curves that indicate important test results.

[0243] Inquiry step **6330** determines if further image correction is needed and if so, the image is appropriately corrected at step **6332**. If no further image correction is needed or after correction of the image at step **6332**, the processed image is output at step **6334**, and a number of different manners for utilizing the processed image result may then occur. The output image data can act as a trigger **6336** for initiating a next process in a testing methodology. This could include activating a doctor consultation starting generation of a treatment protocol, etc. Additionally, the processed image can be utilized as part of a machine learning process **6344** providing a diagnosis or adding to data relating to disease analysis.

[0244] Utilizing the above described techniques, digital images created of test results from a variety of testing processes may be image processed in order to provide a better analysis of the provided test results. Noise, shadows, smudges and other factors that would blur or distort images of test results may be removed from and image of a test result in order to provide more accurate test analysis. This provides great enhancements to online diagnosis and testing methodologies that inherently require the transmission of digital data as part of the process.

[0245] It should be understood that the drawings and detailed description herein are to be regarded in an illustrative rather than a restrictive manner, and are not intended to be limiting to the particular forms and examples disclosed. On the contrary, included are any further modifications, changes, rearrangements, substitutions, alternatives, design choices, and embodiments apparent to those of ordinary skill in the art, without departing from the spirit and scope hereof, as defined by the following claims. Thus, it is intended that the following claims be interpreted to embrace all such further modifications, changes, rearrangements, substitutions, alternatives, design choices, and embodiments.

What is claimed is:

1. A method for image processing medical self-test results, comprising:

receiving a self-test result that provides a visual indication of a test result;

generating a digital image of the visual indication of the test result, the visual image including noise and distortions therein;

processing the digital image using generalized curve field transforms to extract relevant features of the digital image in a presence of the noise and distortions to create a transformed image;

generating a diagnosis based upon the transformed image; and

displaying the diagnosis.

2. The method of claim **1**, wherein the step of processing further comprises:

generating an alignment spectrum of the digital image;

generating a generalized curve field transformation of the digital image from the alignment spectrum;

determining a presence of the at least one geometric shape within the alignment spectrum image.

3. The method of claim 2 further comprising the step of filtering the alignment spectrum image to remove at least one predetermined geometric shape.

4. The method of claim 3 further including the step of determining a presence of a second at least one predetermined geometric shape within the alignment spectrum image.

5. The method of claim 2, wherein the step of generating an orientation field further comprises:

determining for each pixel within the digital image an orientation line from a plurality of possible lines based upon an intensity response for the each line; and

determining for each pixel within the digital image a reliability factor for the determined orientation line.

6. The method of claim 1, wherein the step of processing further comprises removing shadows from the digital image to create the transformed image.

7. A method for image processing medical self-test results, comprising:

receiving a digital image of a visual indication of a test result, the visual image including noise and distortions therein;

processing the digital image using generalized curve field transforms to extract relevant features of the digital image in a presence of the noise and distortions to create a transformed image; and

generating a diagnosis based upon the transformed image.

8. The method of claim 7, wherein the step of processing further comprises:

generating an alignment spectrum of the digital image;

generating a generalized curve field transformation of the digital image from the alignment spectrum;

determining a presence of the at least one geometric shape within the alignment spectrum image.

9. The method of claim 8 further comprising the step of filtering the alignment spectrum image to remove at least one predetermined geometric shape.

10. The method of claim 9 further including the step of determining a presence of a second at least one predetermined geometric shape within the alignment spectrum image.

11. The method of claim 8, wherein the step of generating an orientation field further comprises:

determining for each pixel within the digital image an orientation line from a plurality of possible orientation lines based upon an intensity response for the orientation line; and

determining for each pixel within the digital image a reliability factor for the determined orientation line.

12. The method of claim 7, wherein the step of processing further comprises removing shadows from the digital image to create the transformed image.

13. A method for image processing medical self-test results, comprising:

receiving a self-test result that provides a visual indication of a test result;

generating a digital image of the visual indication of the test result, the visual image including noise and distortions therein;

generating an alignment spectrum of the digital image;

generating a generalized curve field transformation of the digital image from the alignment spectrum;

determining a presence of the at least one geometric shape within the alignment spectrum image;

filtering the alignment spectrum image to remove at least one predetermined geometric shape;

generating a diagnosis based upon the processed test results; and

displaying the diagnosis.

14. The method of claim 13 further including the step of determining a presence of a second at least one predetermined geometric shape within the alignment spectrum image.

15. The method of claim 13, wherein the step of generating an orientation field further comprises:

determining for each pixel within the digital image an orientation line from a plurality of possible orientation lines based upon an intensity response for the orientation line; and

determining for each pixel within the digital image a reliability factor for the determined orientation line.

16. The method of claim 13, wherein the step of processing further comprises removing shadows from the digital image to create the transformed image.

17. The method of claim 13, wherein the step of generating the alignment spectrum image further comprises:

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