PRIOR ART

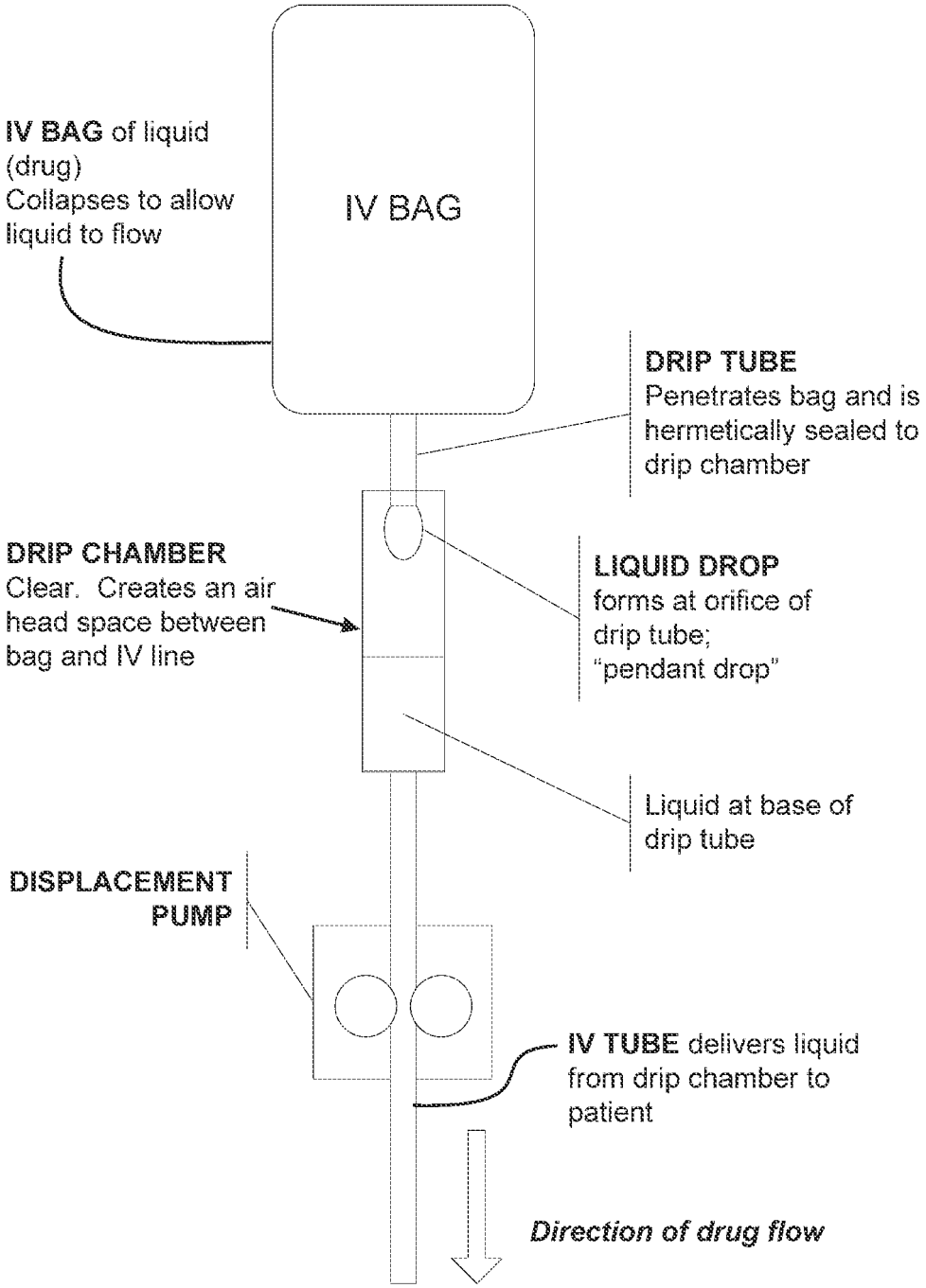


Fig. 1

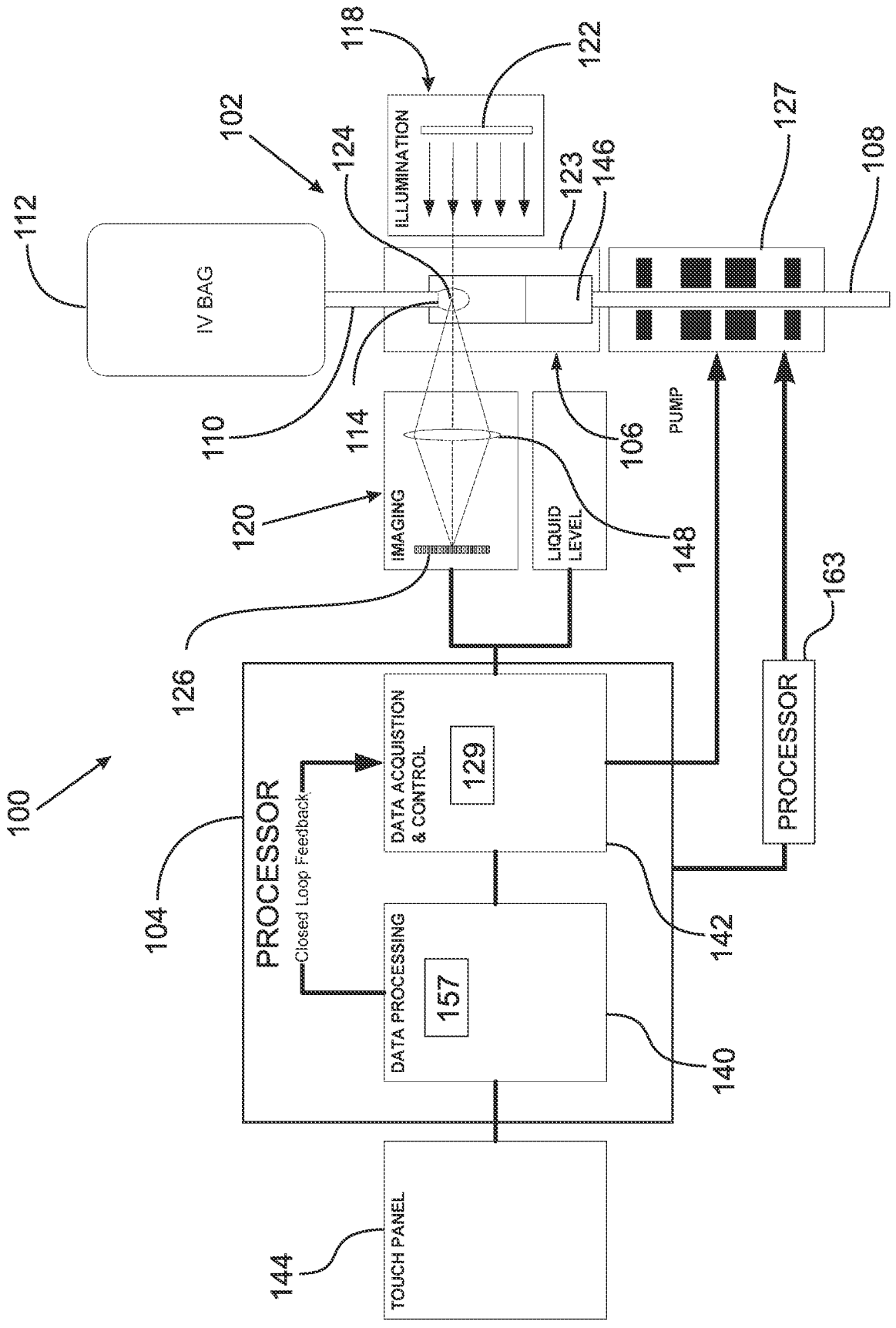

100
102
104
PROCESSOR
Closed Loop Feedback
DATA ACQUISITION & CONTROL
129
DATA PROCESSING
157
TOUCH PANEL
144
140
142
PROCESSOR
163
112
IV BAG
110
118
ILLUMINATION
122
124
123
146
127
108
114
106
PUMP
120
IMAGING
LIQUID LEVEL
148
126

Fig. 2

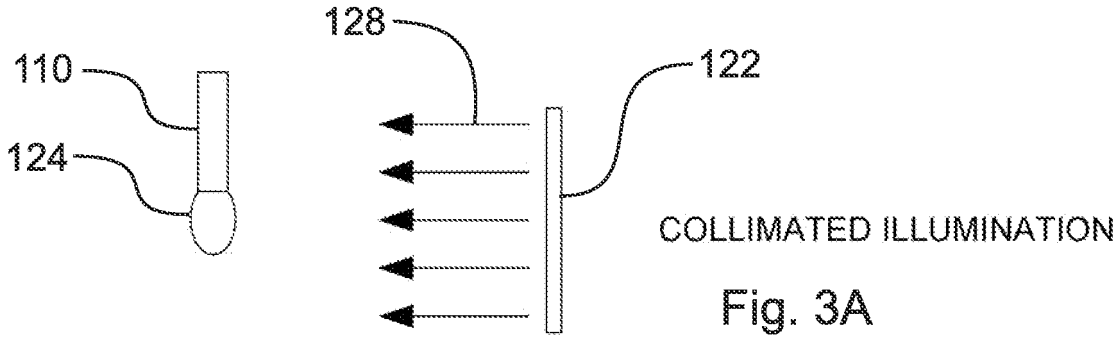


Fig. 3A

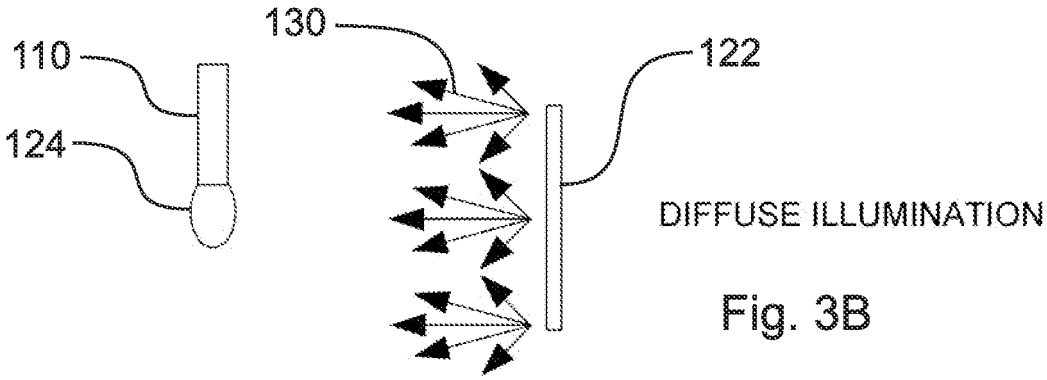


Fig. 3B

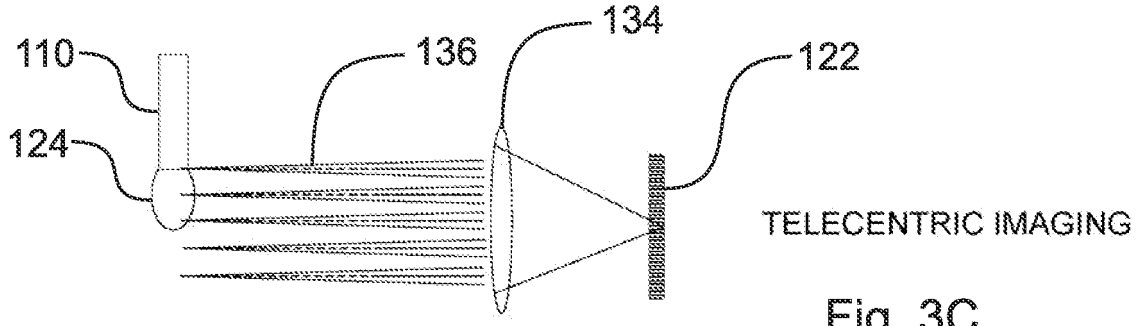


Fig. 3C

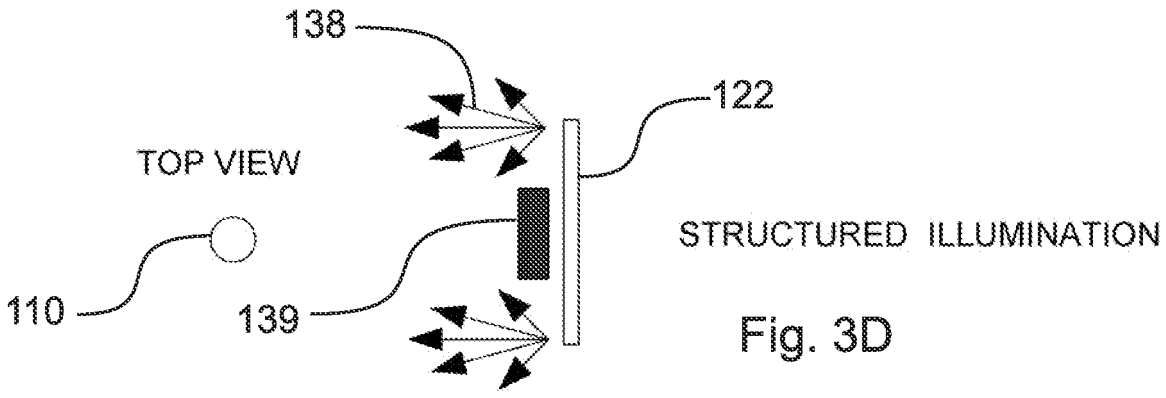


Fig. 3D

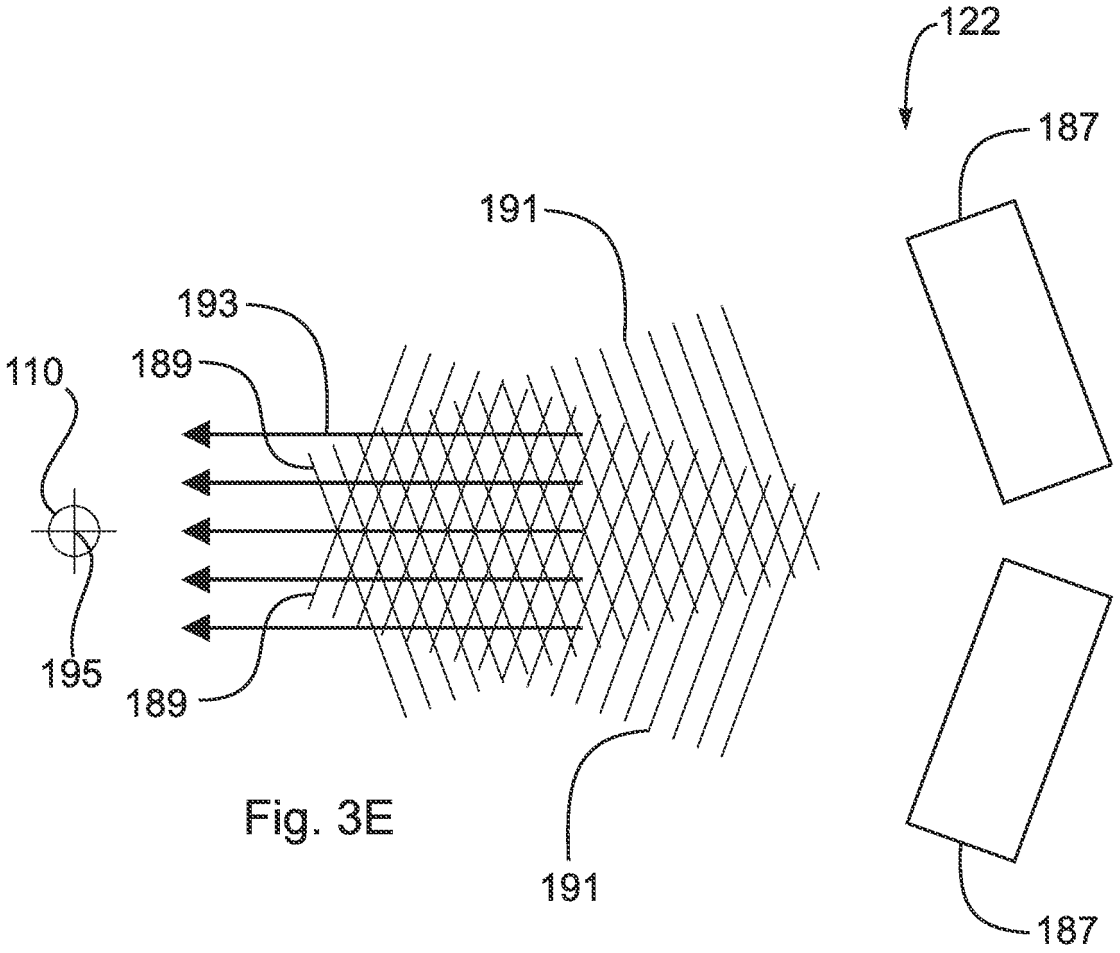

122
187
191
193
189
110
195
189
191
187

Fig. 3E

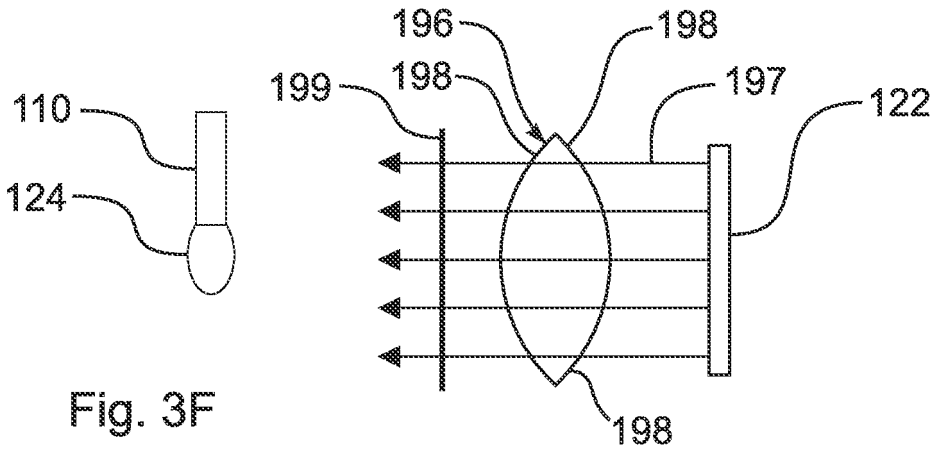

196
198
199
198
197
122
110
124
198

Fig. 3F

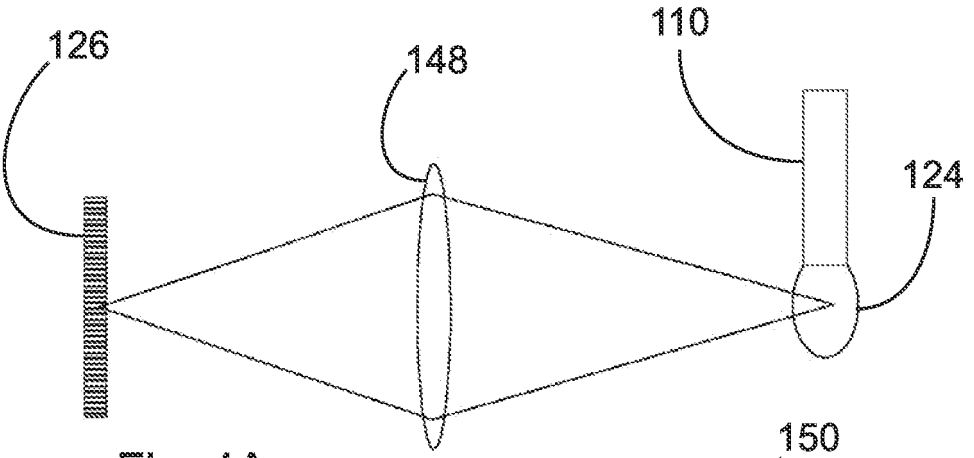


Fig. 4A

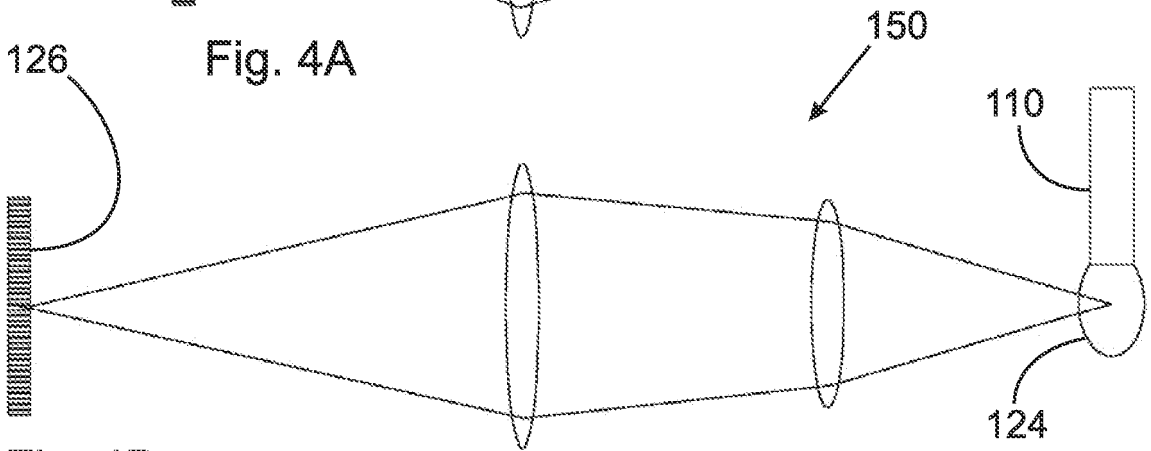


Fig. 4B

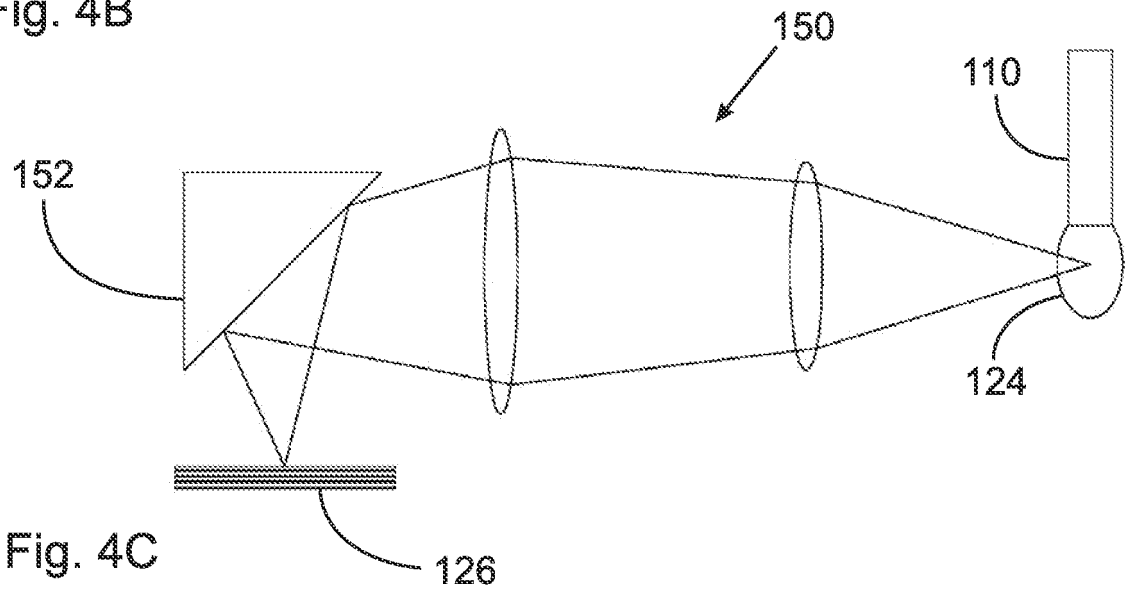


Fig. 4C

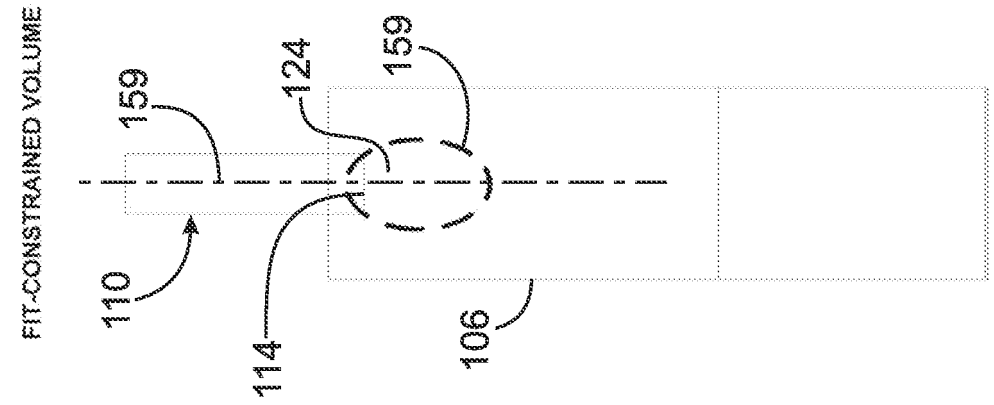


Fig. 5C

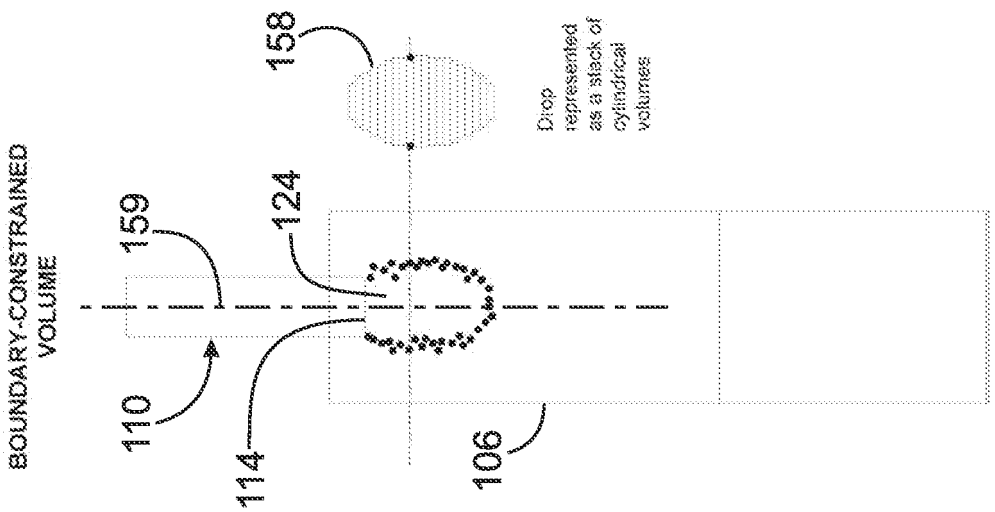


Fig. 5B

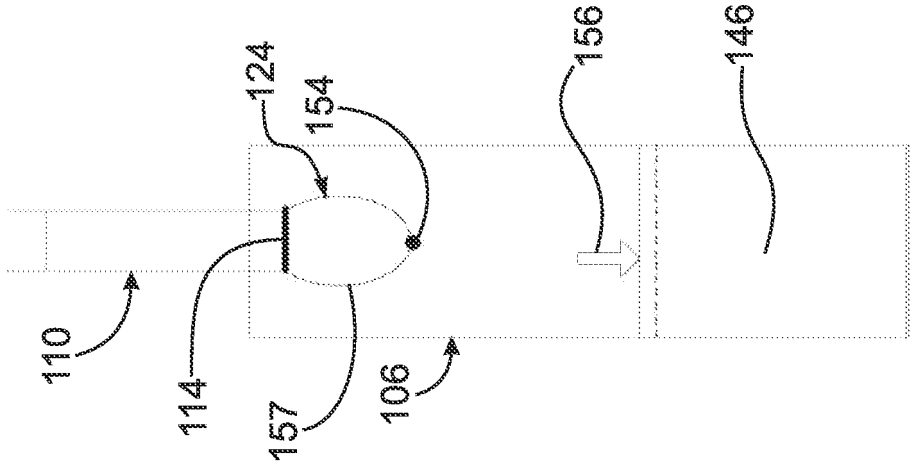


Fig. 5A

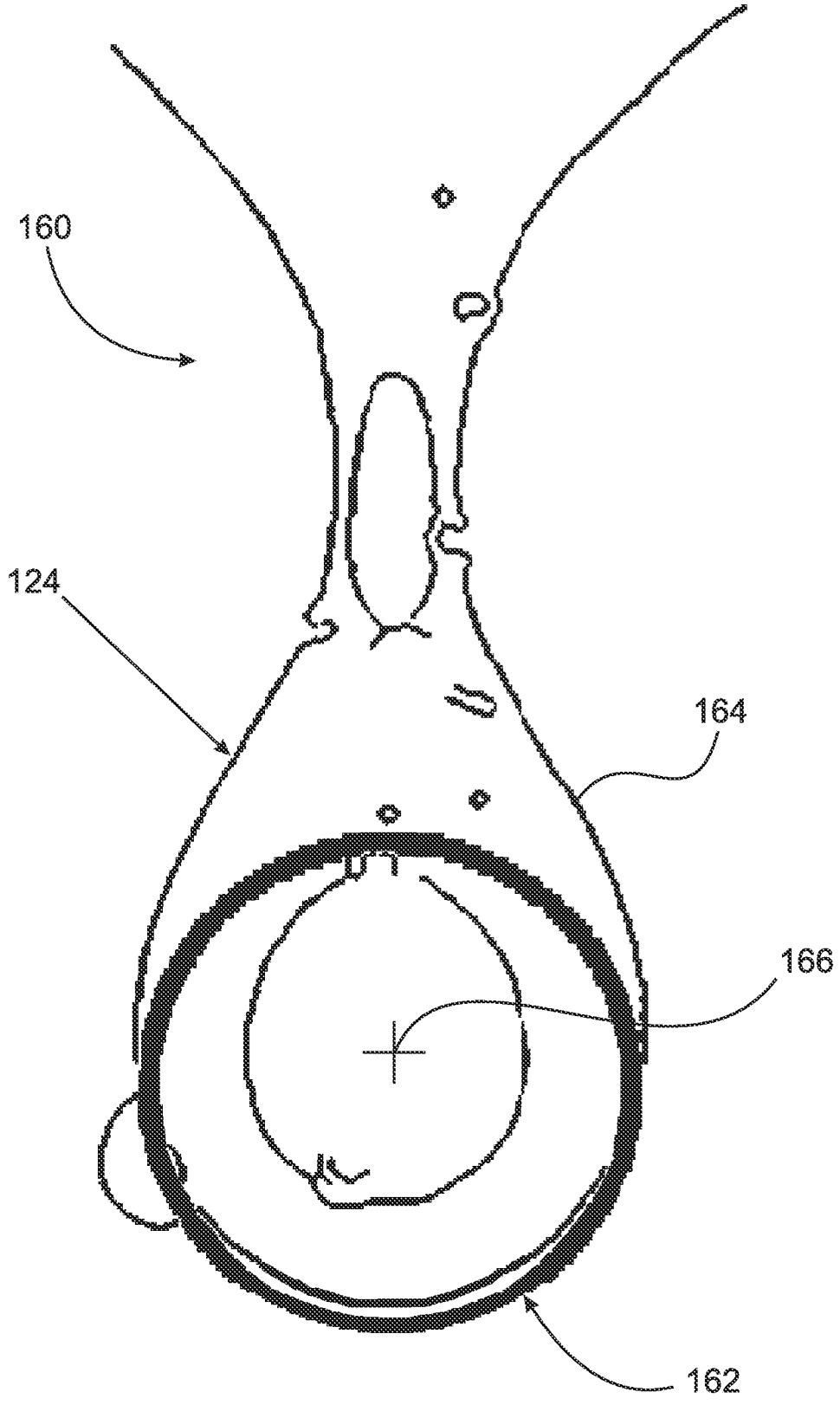


Fig. 6

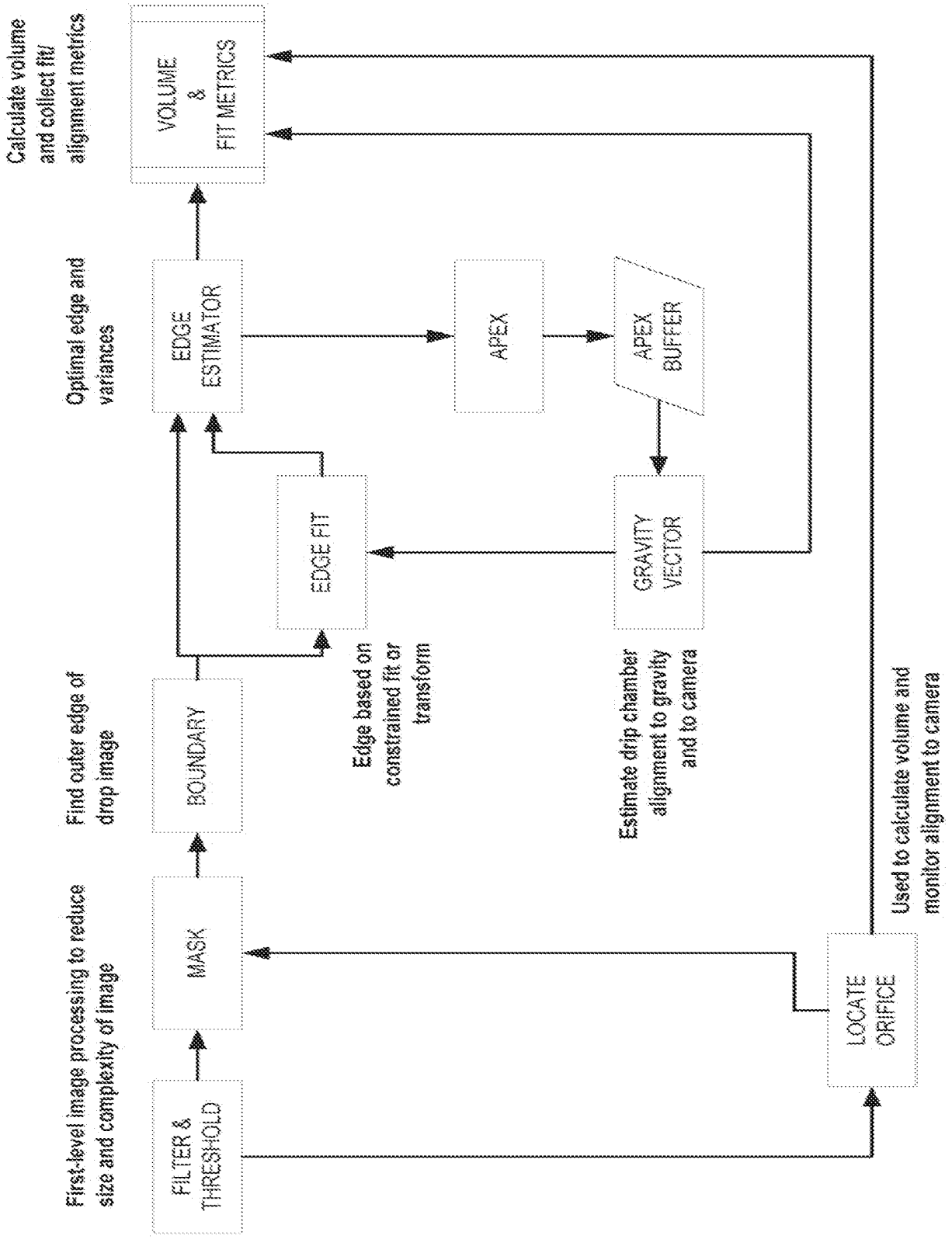

FILTER & THRESHOLD
MASK
BOUNDARY
EDGE ESTIMATOR
VOLUME & FIT METRICS
EDGE FIT
APEX
APEX BUFFER
GRAVITY VECTOR
LOCATE ORIFICE
First-level image processing to reduce size and complexity of image
Find outer edge of drop image
Optimal edge and variances
Calculate volume and collect fit/ alignment metrics
Edge based on constrained fit or transform
Estimate drip chamber alignment to gravity and to camera
Used to calculate volume and monitor alignment to camera

Fig. 7

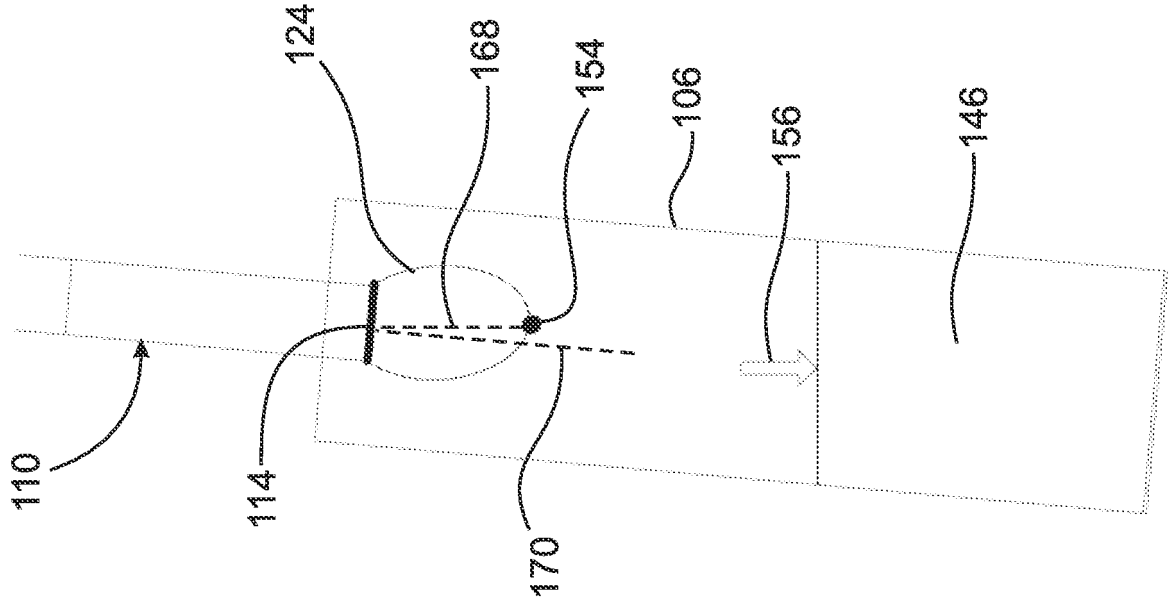

124
168
154
106
156
146
110
114
170

Fig. 8B

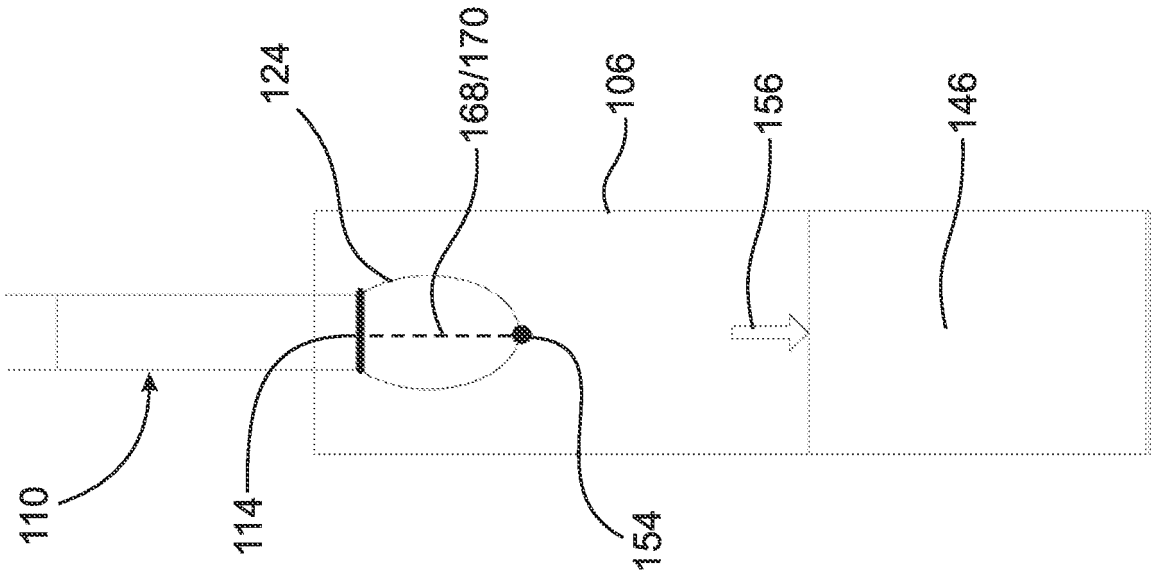

124
168/170
106
156
146
110
114
154

Fig. 8A

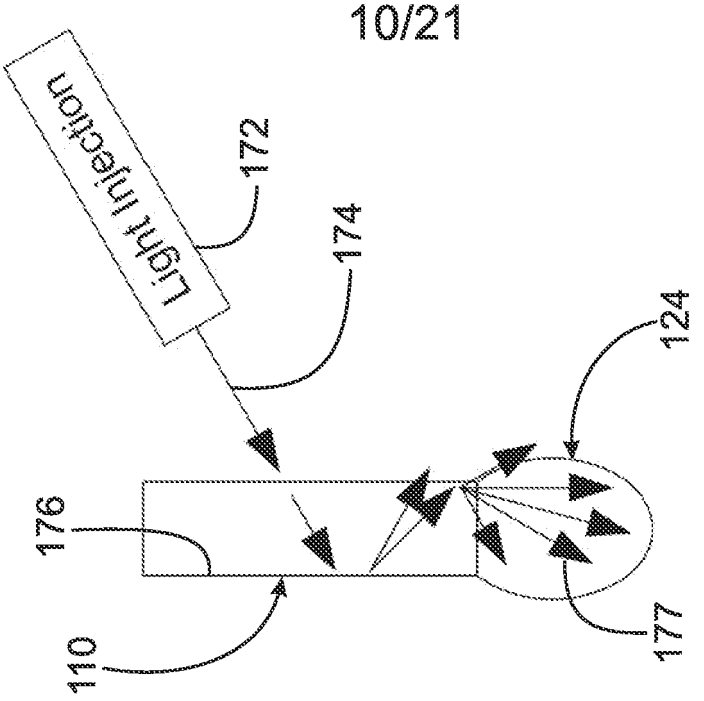

Light Injection
172
174
124
176
110
177

Fig. 9B

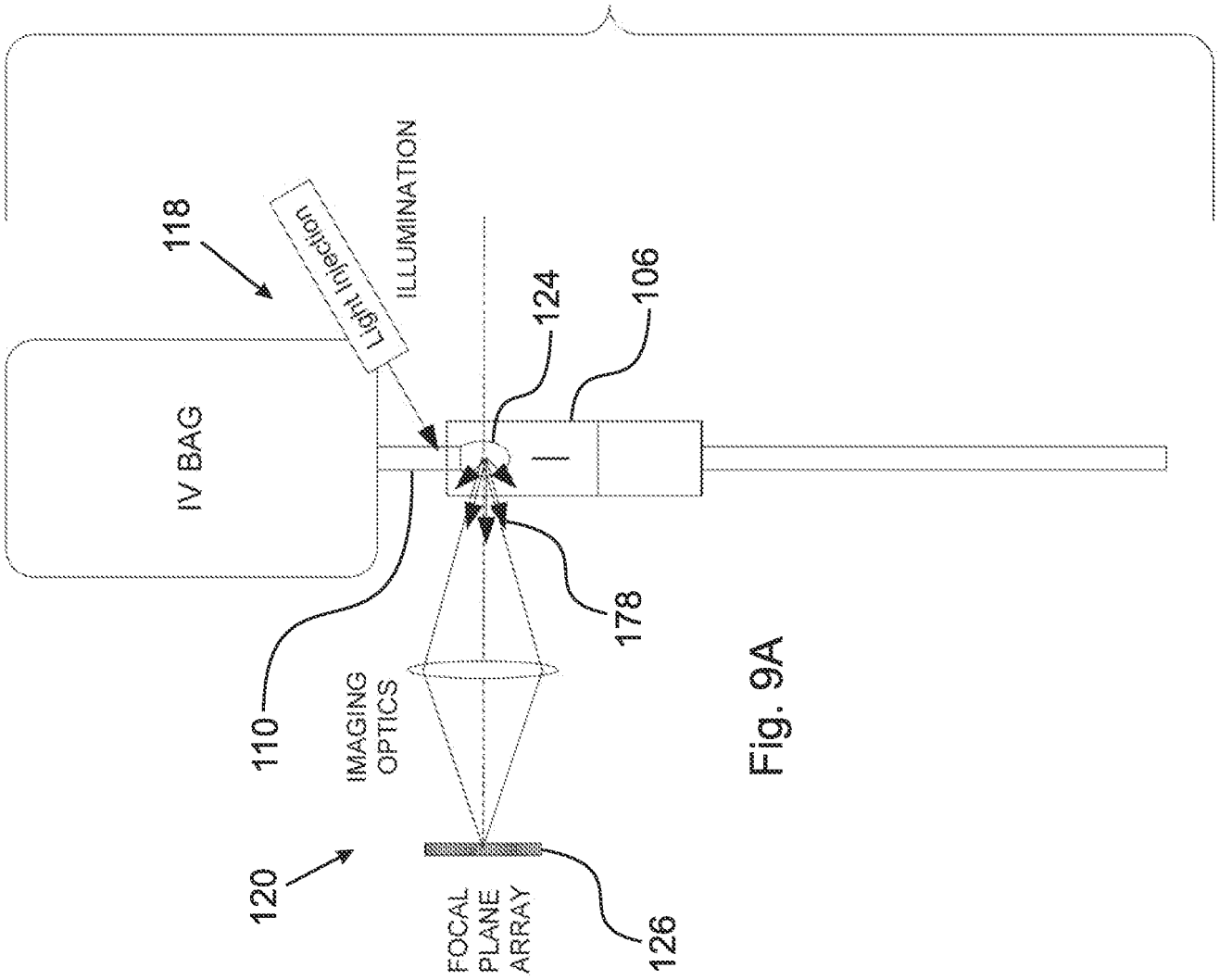

118
Light Injection
ILLUMINATION
124
106
IV BAG
178
110
IMAGING OPTICS
120
FOCAL PLANE ARRAY
126

Fig. 9A

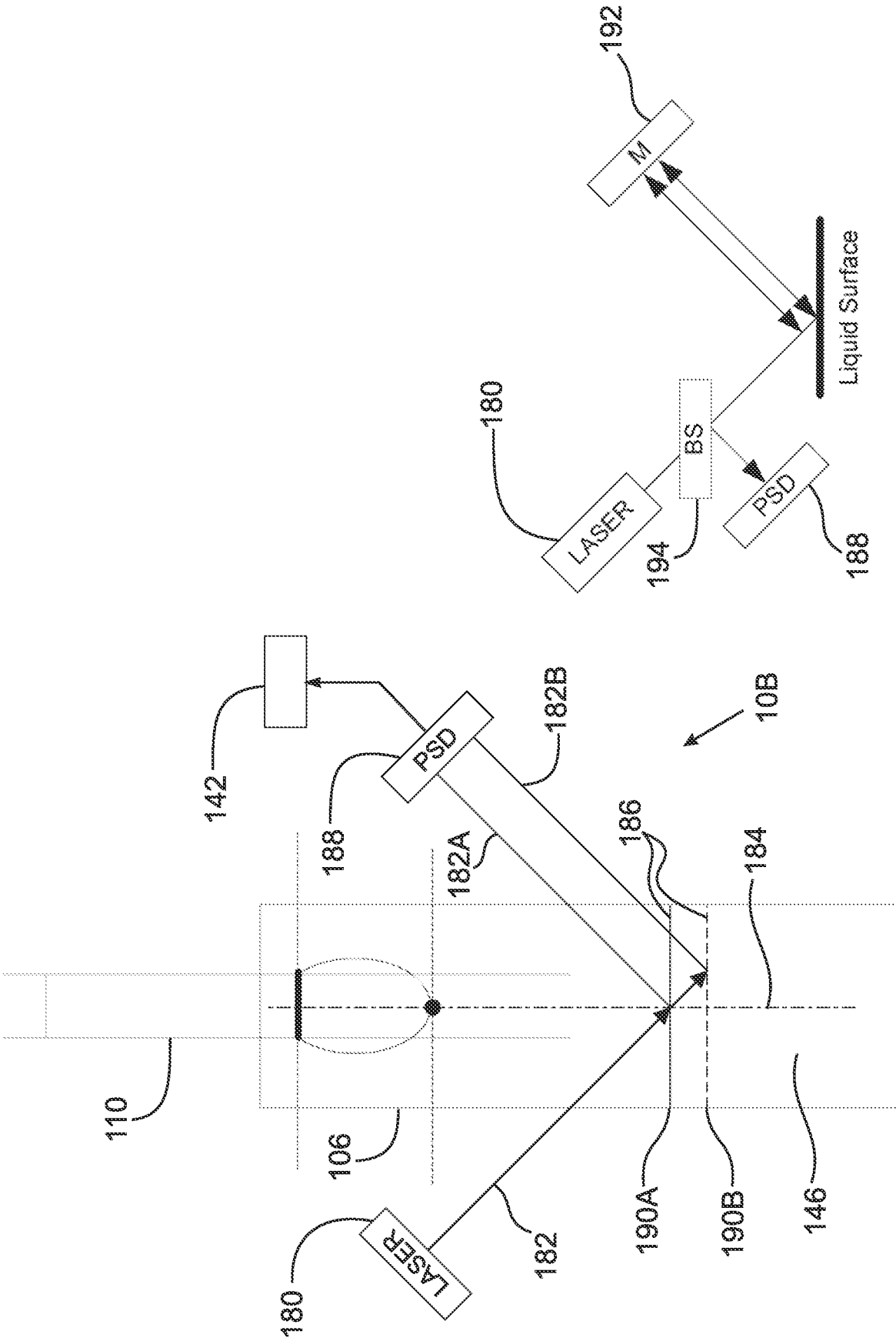


Fig. 10B

Fig. 10A

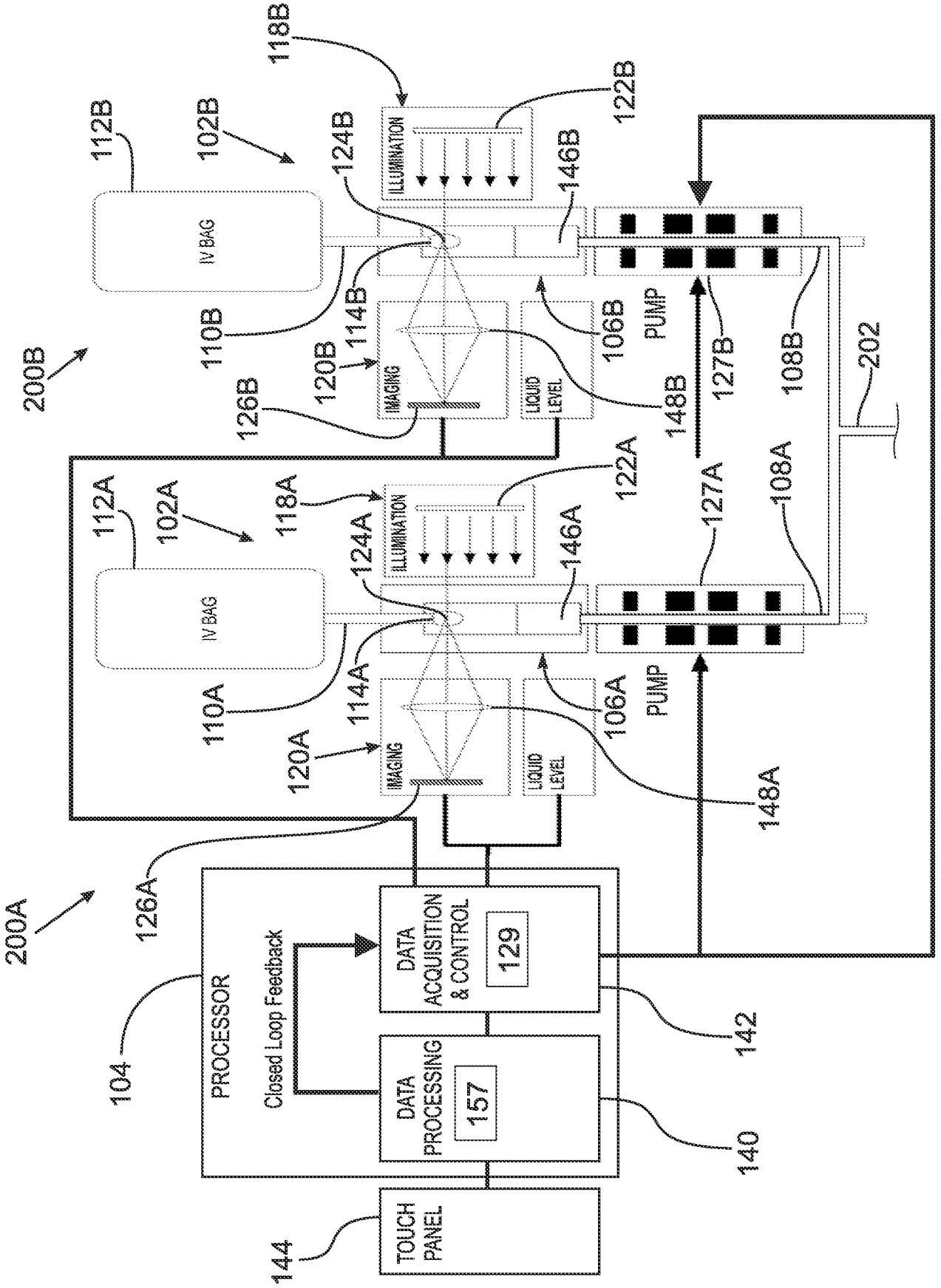

200A
200B
104
PROCESSOR
Closed Loop Feedback
DATA ACQUISITION & CONTROL
129
DATA PROCESSING
157
TOUCH PANEL
140
142
144
126A
126B
IV BAG
112A
112B
102A
102B
110A
110B
ILLUMINATION
118A
118B
122A
122B
124A
124B
IMAGING
120A
120B
LIQUID LEVEL
114A
114B
146A
146B
PUMP
106A
106B
127A
127B
148A
148B
108A
108B
202

Fig. 11

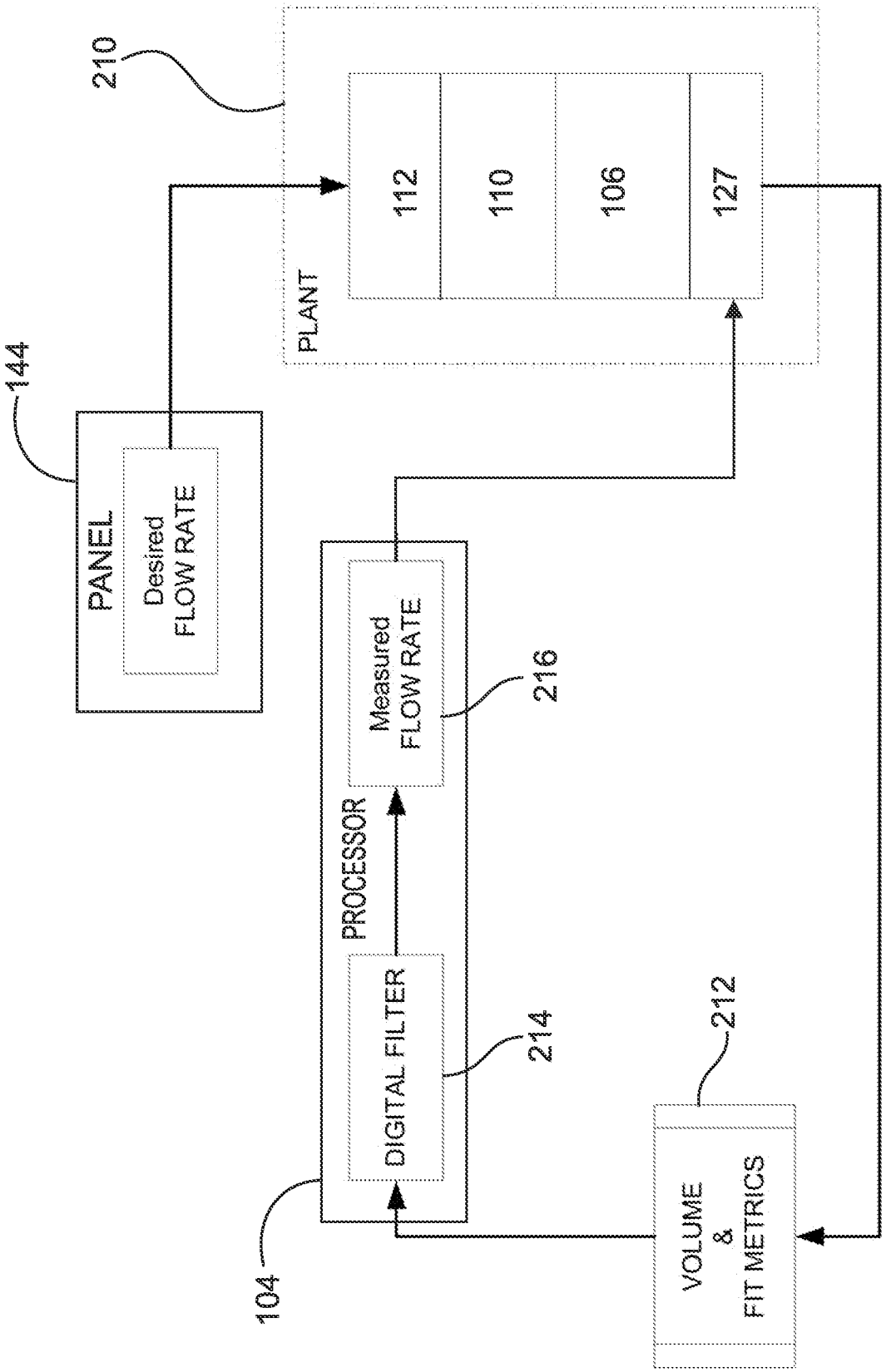

210
PLANT
112
110
106
127
144
PANEL
Desired
FLOW RATE
PROCESSOR
Measured
FLOW RATE
216
DIGITAL FILTER
214
212
VOLUME
&
FIT METRICS
104

Fig. 12

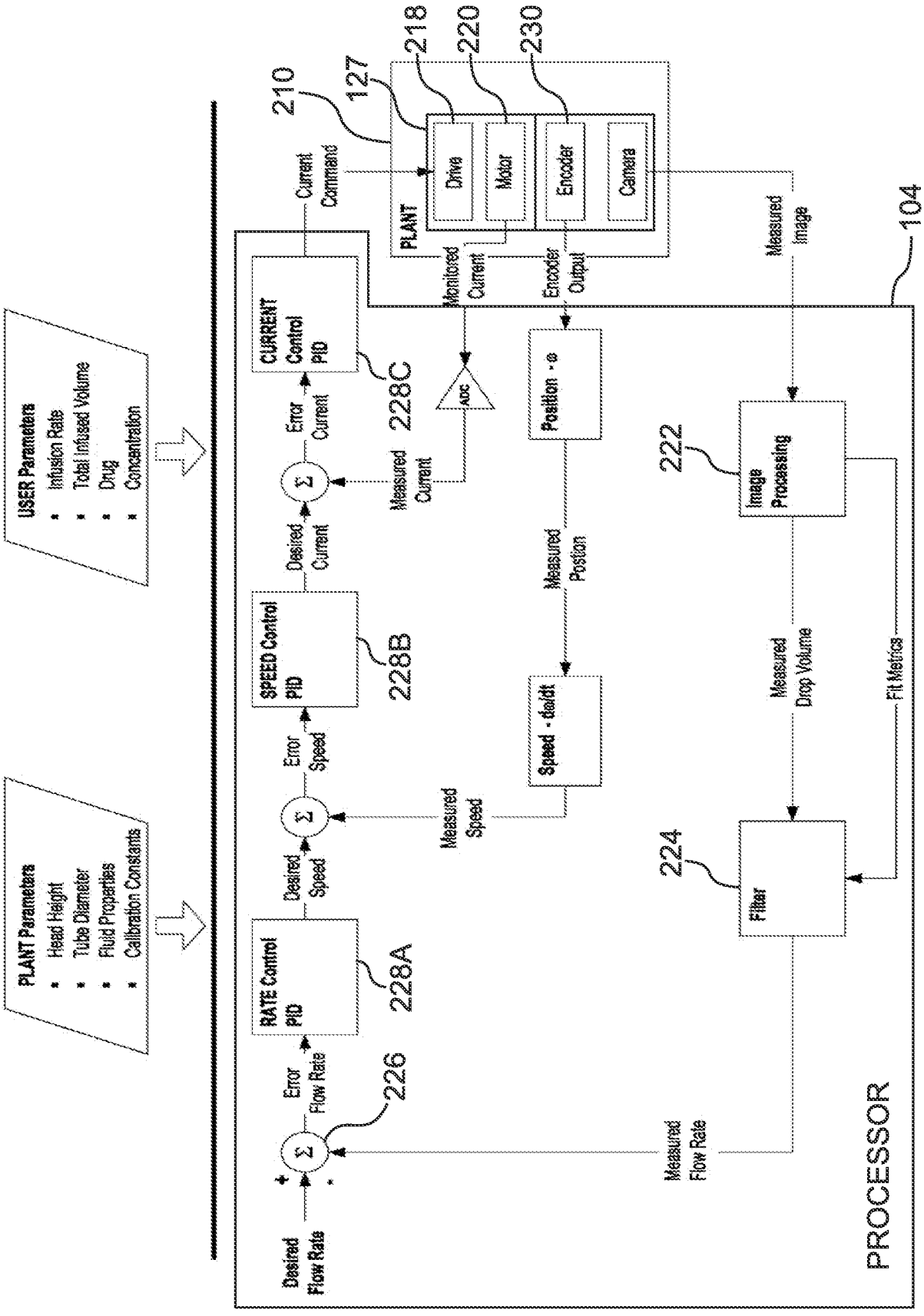

USER Parameters
Infusion Rate
Total Infused Volume
Drug
Concentration
PLANT Parameters
Head Height
Tube Diameter
Fluid Properties
Calibration Constants
PROCESSOR
RATE Control PID
SPEED Control PID
CURRENT Control PID
228A
228B
228C
226
224
222
210
127
218
220
230
104
PLANT
Drive
Motor
Encoder
Camera
Current Command
Monitored Current
Encoder Output
Measured Image
Desired Flow Rate
Error Flow Rate
Desired Speed
Error Speed
Measured Speed
Desired Current
Error Current
Measured Current
Measured Position
Measured Flow Rate
Measured Drop Volume
Fit Metrics
Position - θ
Speed - dθ/dt
Image Processing
Filter
ADC

Fig. 13

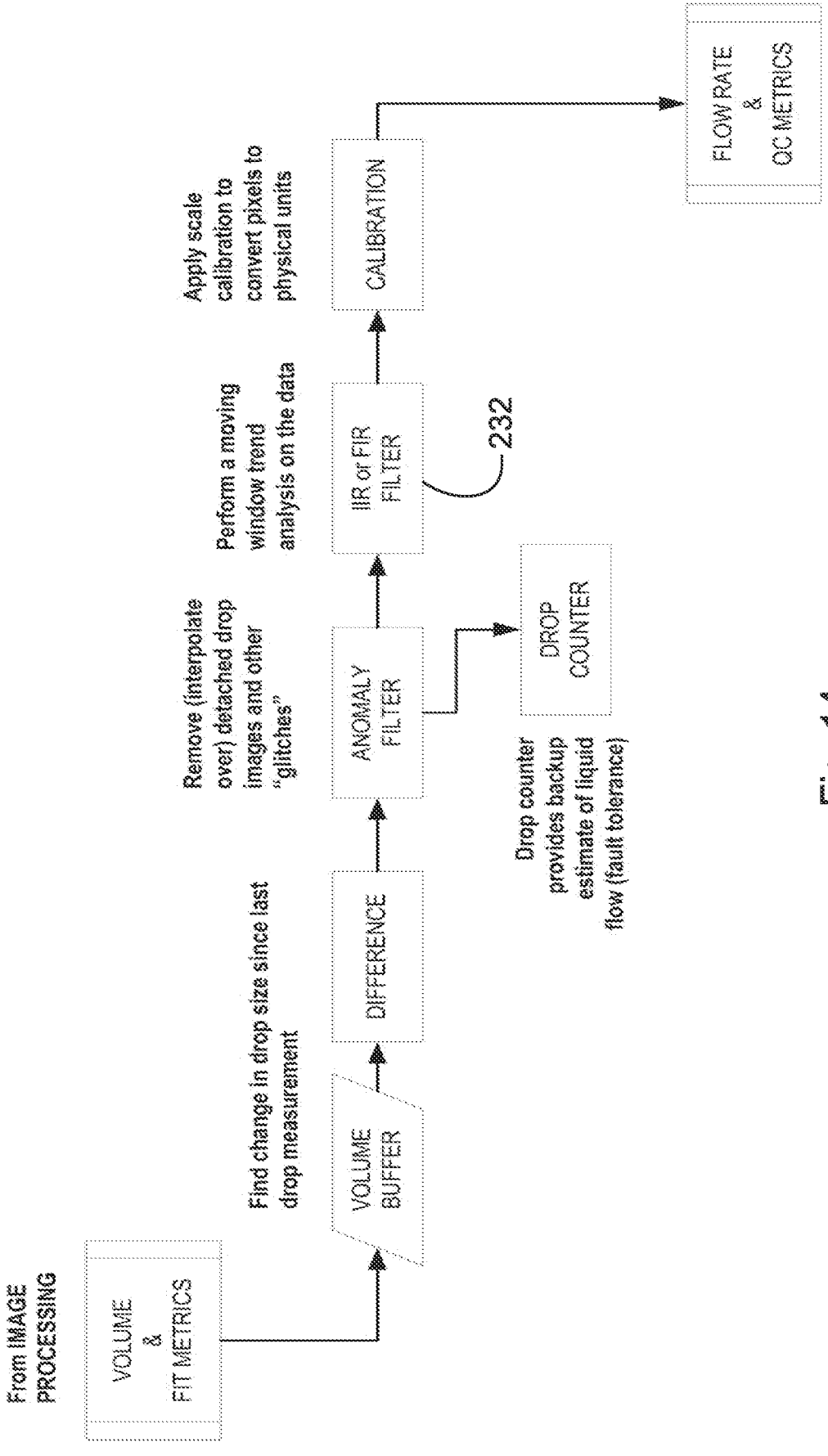

From IMAGE PROCESSING
VOLUME & FIT METRICS
VOLUME BUFFER
Find change in drop size since last drop measurement
DIFFERENCE
Remove (interpolate over) detached drop images and other "glitches"
ANOMALY FILTER
Drop counter provides backup estimate of liquid flow (fault tolerance)
DROP COUNTER
Perform a moving window trend analysis on the data
IIR or FIR FILTER
232
Apply scale calibration to convert pixels to physical units
CALIBRATION
FLOW RATE & QC METRICS

Fig. 14

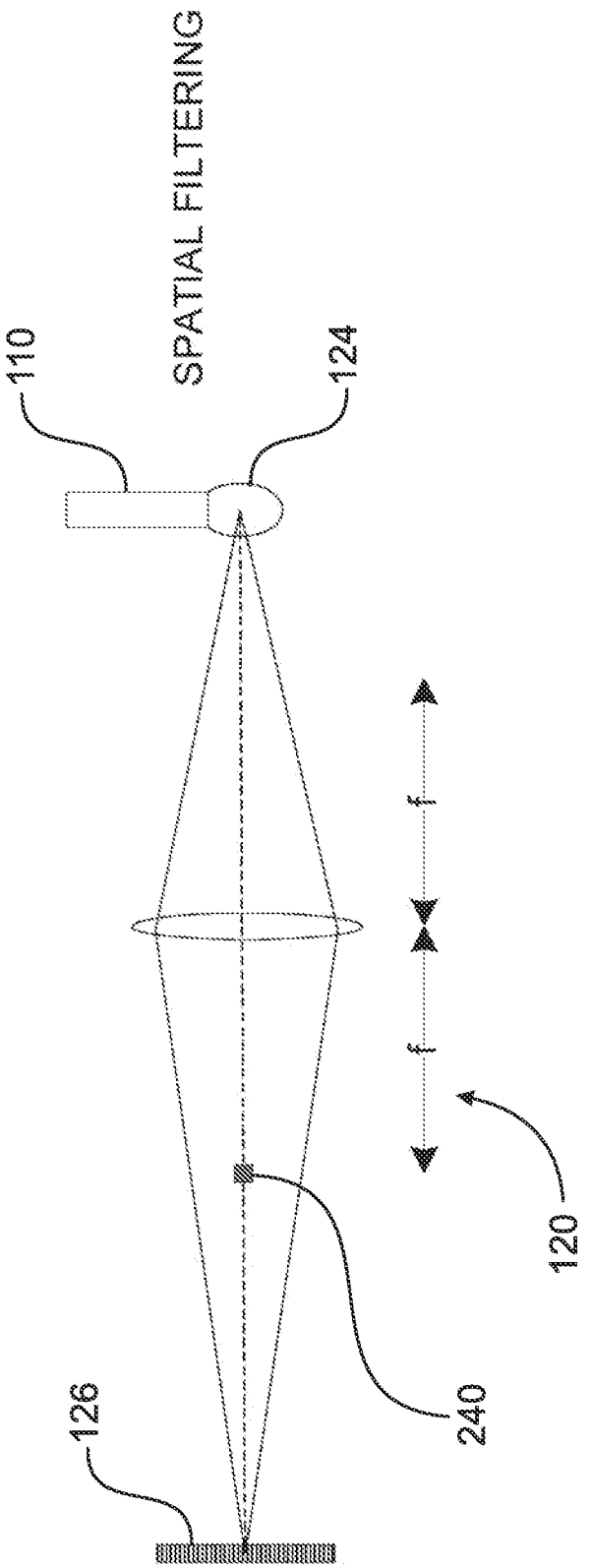


Fig. 15

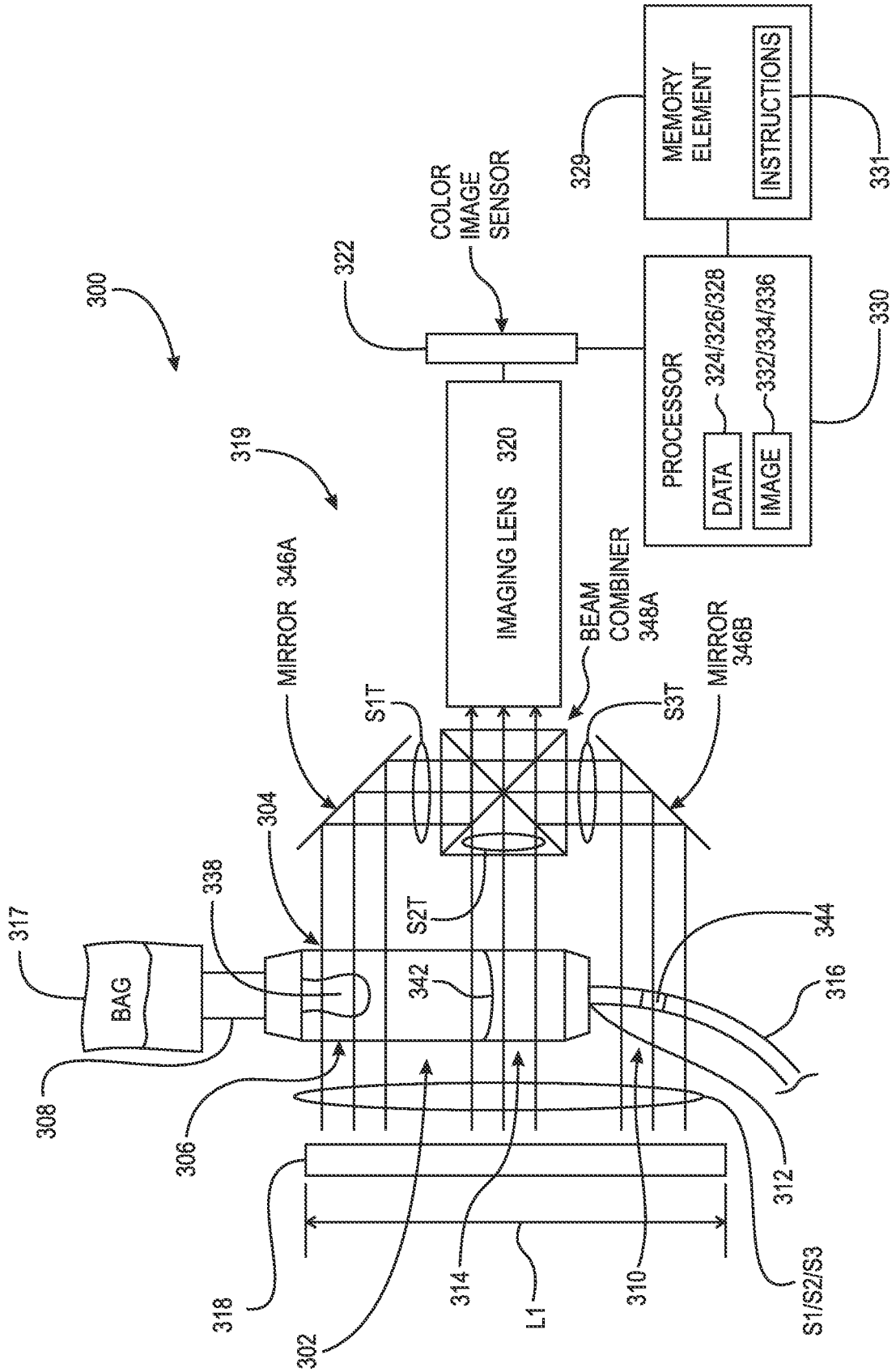

300
319
322
COLOR IMAGE SENSOR
329
MEMORY ELEMENT
INSTRUCTIONS
331
PROCESSOR
324/326/328
DATA
IMAGE
332/334/336
330
IMAGING LENS 320
MIRROR 346A
BEAM COMBINER 348A
MIRROR 346B
S1T
S2T
S3T
304
338
317
BAG
342
344
316
308
306
312
318
314
L1
310
302
S1/S2/S3

Fig. 16

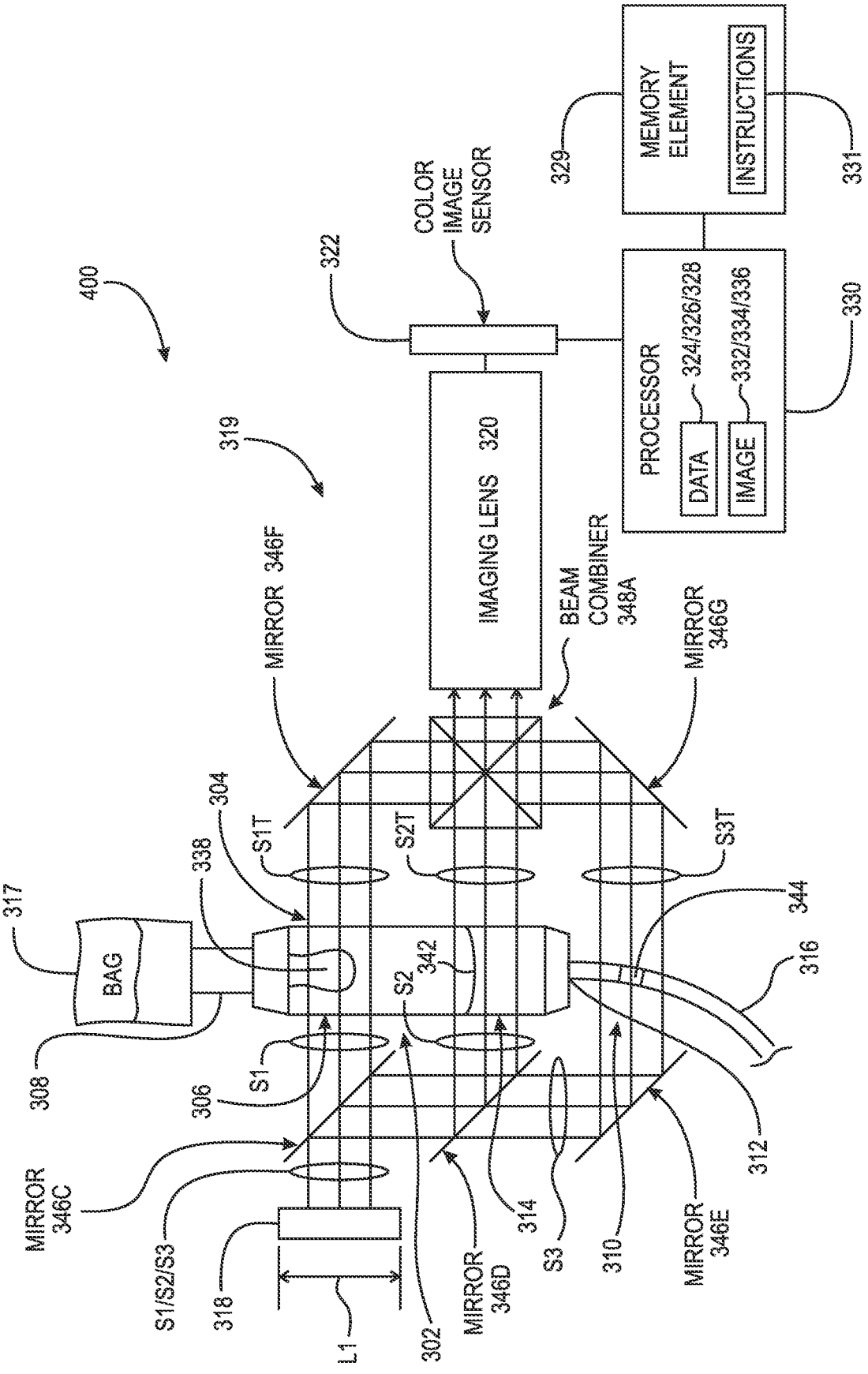

400
322
COLOR IMAGE SENSOR
329
MEMORY ELEMENT
INSTRUCTIONS
331
319
IMAGING LENS 320
PROCESSOR
DATA
IMAGE
324/326/328
332/334/336
330
MIRROR 346F
BEAM COMBINER 348A
MIRROR 346G
304
S1T
S2T
S3T
338
317
BAG
344
342
S2
316
308
306
S1
MIRROR 346C
312
S1/S2/S3
314
318
MIRROR 346D
S3
310
MIRROR 346E
L1
302

Fig. 17

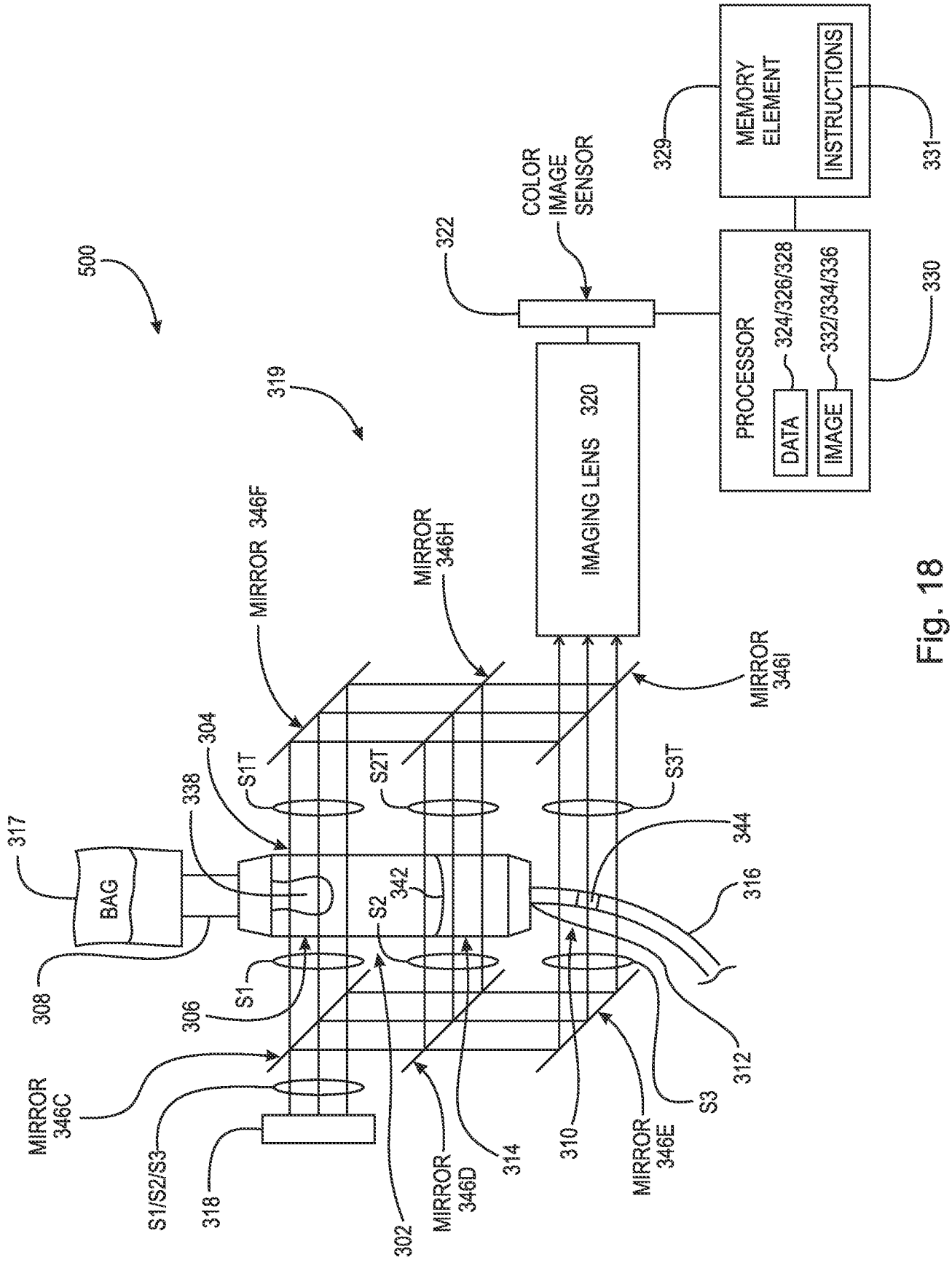

500
319
317
BAG
308
306
338
304
S1T
S2T
S3T
344
316
312
S1
S2
342
S3
MIRROR 346F
MIRROR 346H
MIRROR 346I
IMAGING LENS 320
322
COLOR IMAGE SENSOR
PROCESSOR
DATA
IMAGE
324/326/328
332/334/336
330
MEMORY ELEMENT
INSTRUCTIONS
329
331
MIRROR 346C
S1/S2/S3
318
302
MIRROR 346D
314
310
MIRROR 346E

Fig. 18

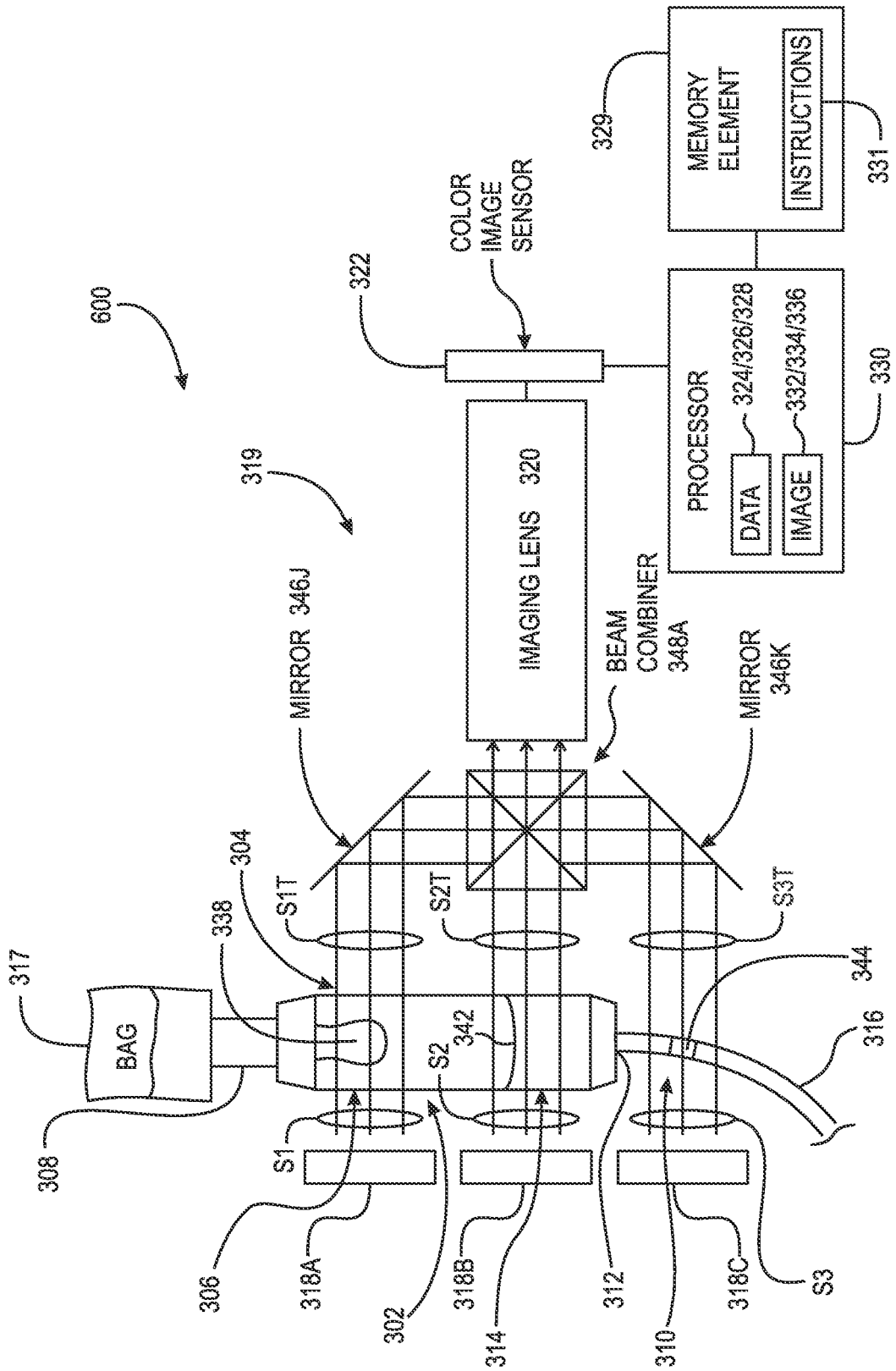

600
322
COLOR IMAGE SENSOR
329
MEMORY ELEMENT
INSTRUCTIONS
331
319
IMAGING LENS 320
PROCESSOR
324/326/328
DATA
IMAGE
332/334/336
330
MIRROR 346J
BEAM COMBINER 348A
MIRROR 346K
304
S1T
S2T
S3T
338
317
BAG
344
342
S2
316
308
S1
306
318A
302
318B
314
312
310
318C
S3

Fig. 19

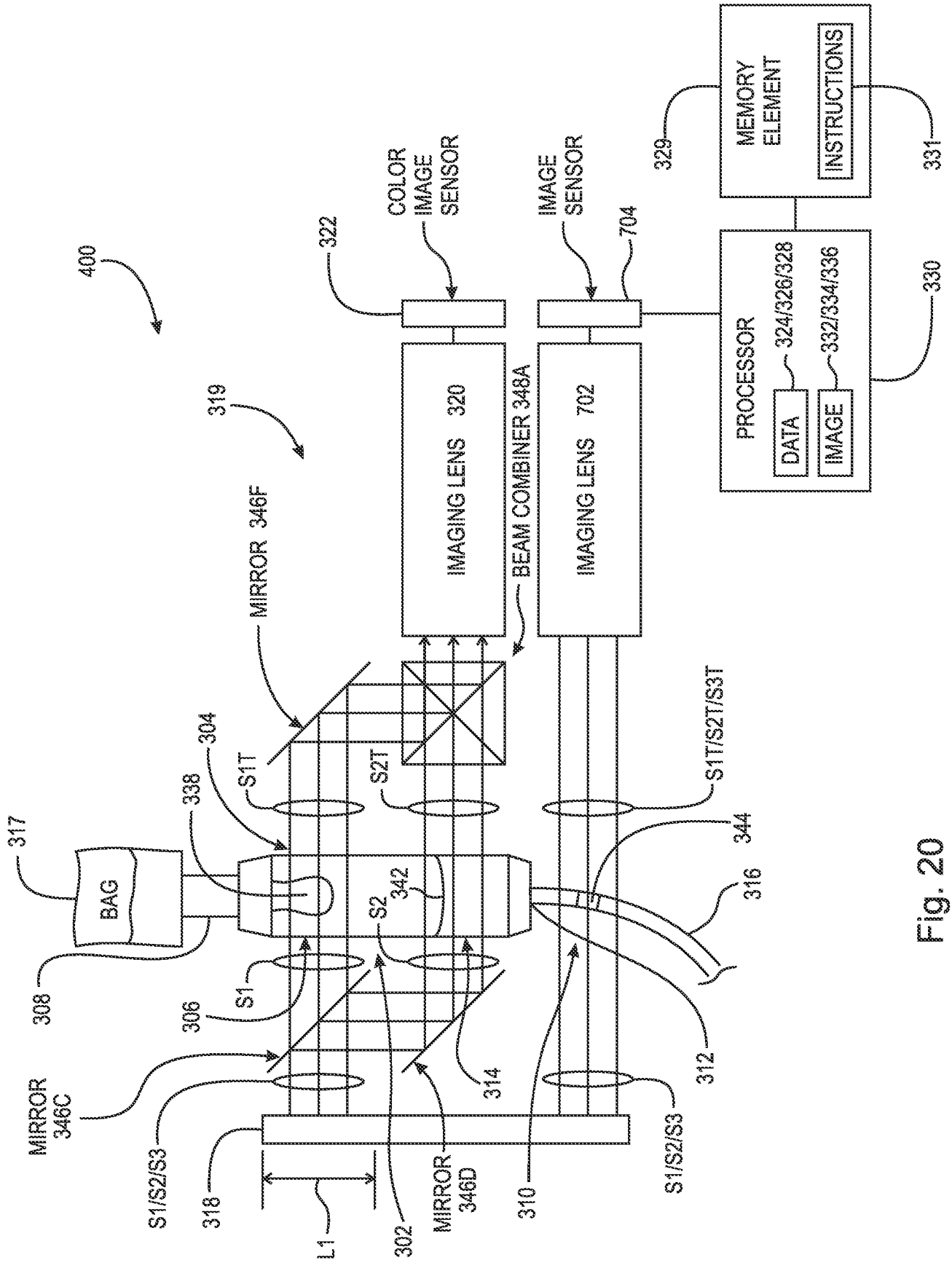

400
322
COLOR IMAGE SENSOR
704
IMAGE SENSOR
329
MEMORY ELEMENT
INSTRUCTIONS
331
319
IMAGING LENS 320
BEAM COMBINER 348A
IMAGING LENS 702
PROCESSOR
DATA
324/326/328
IMAGE
332/334/336
330
MIRROR 346F
304
S1T
S2T
S1T/S2T/S3T
317
338
344
BAG
S2
342
316
308
S1
306
MIRROR 346C
314
312
S1/S2/S3
318
MIRROR 346D
310
S1/S2/S3
L1
302

Fig. 20