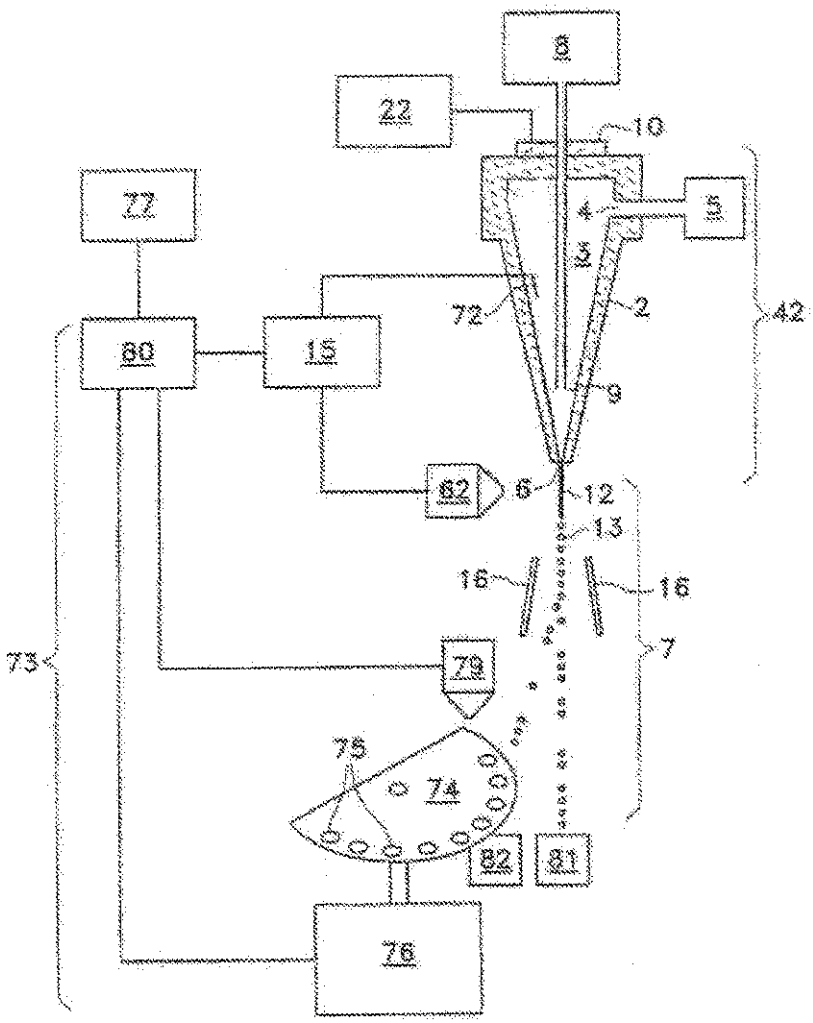


FIG. 1
PRIOR ART

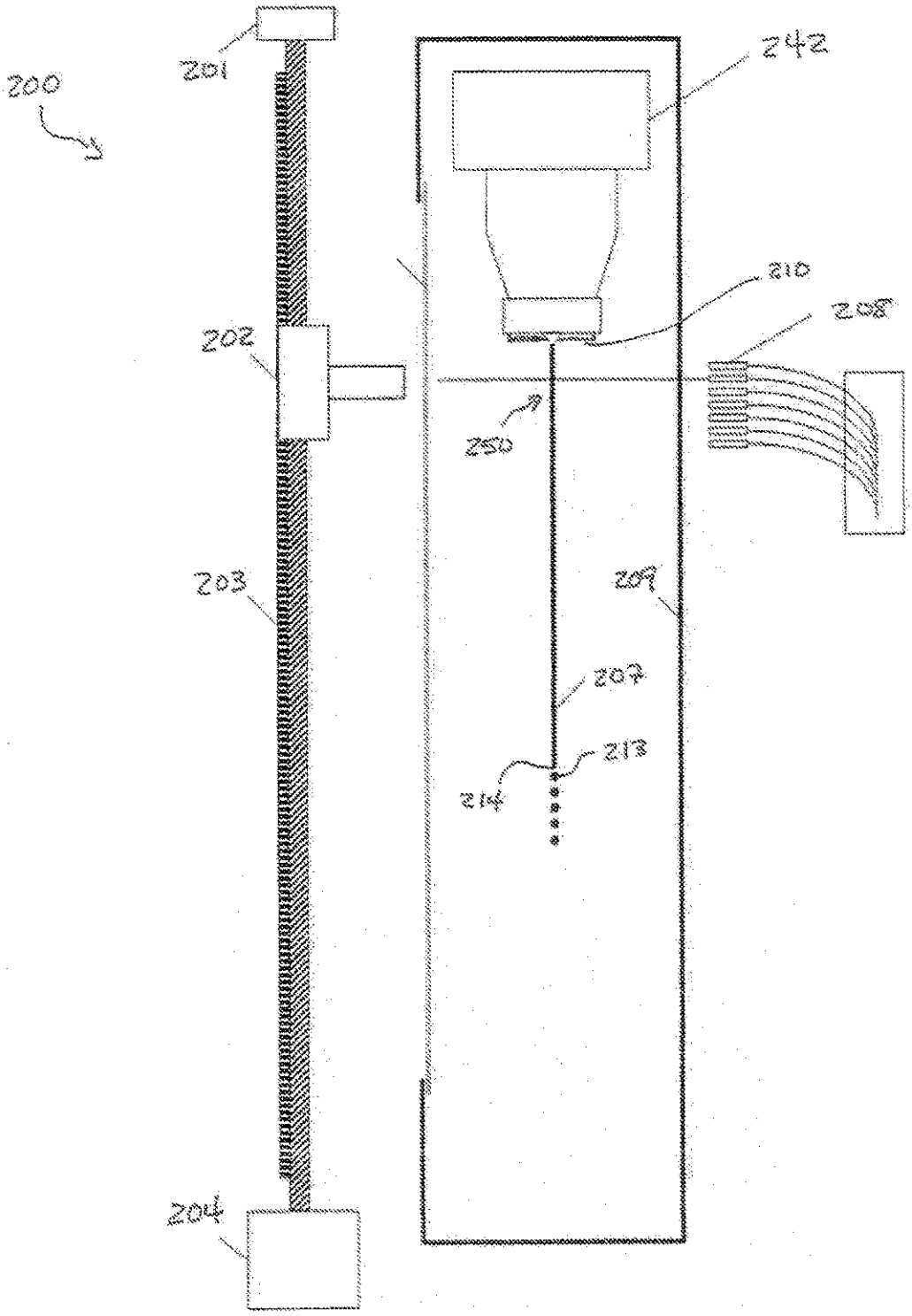


FIG. 2

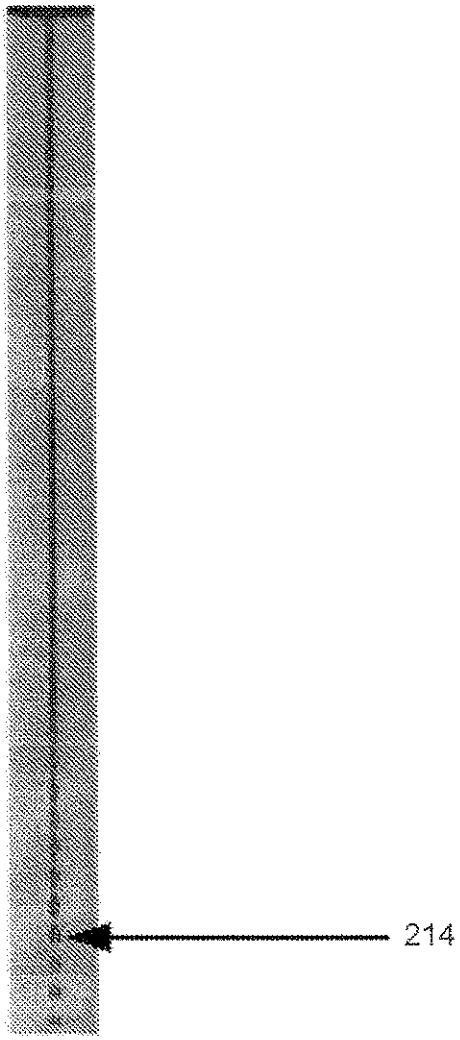


FIG. 3

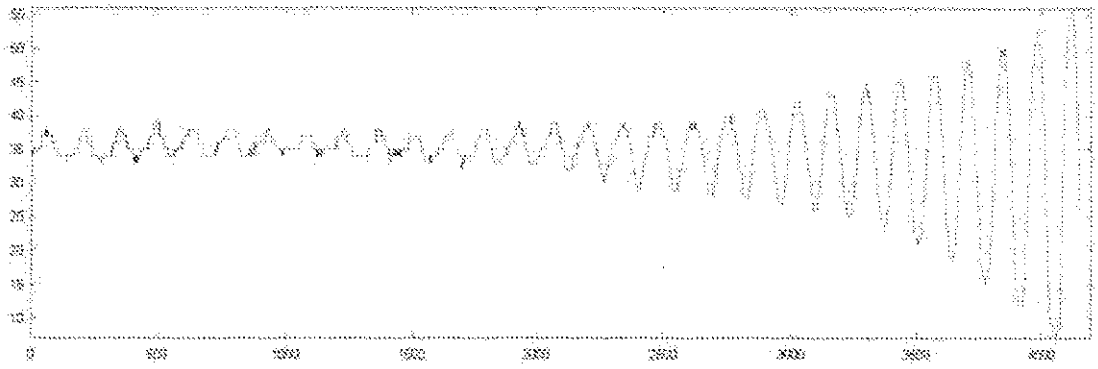


FIG. 4

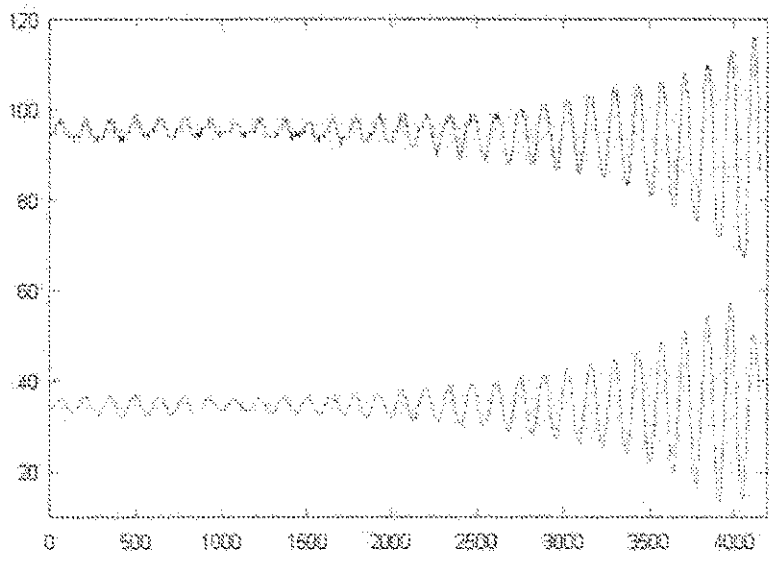


FIG. 5A

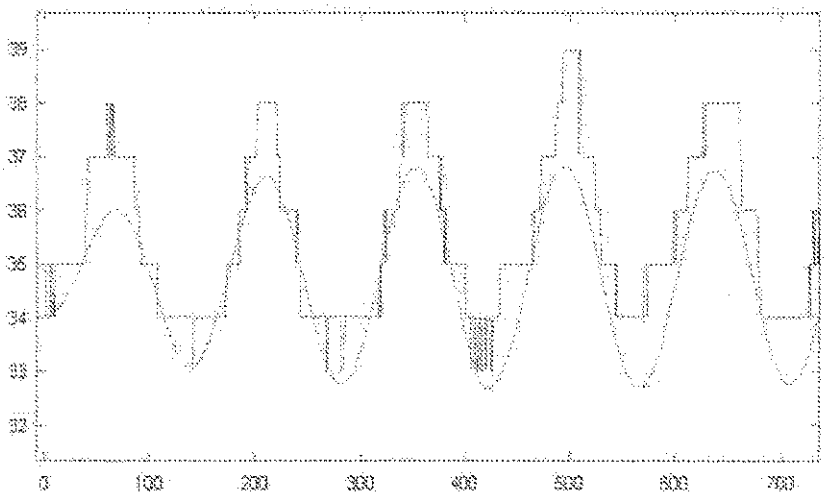


FIG. 5B

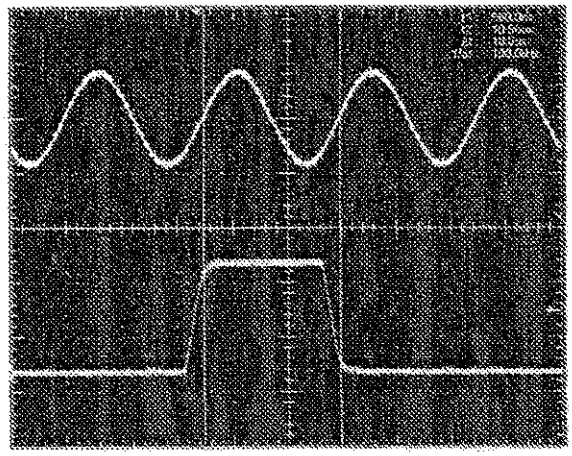


FIG. 6

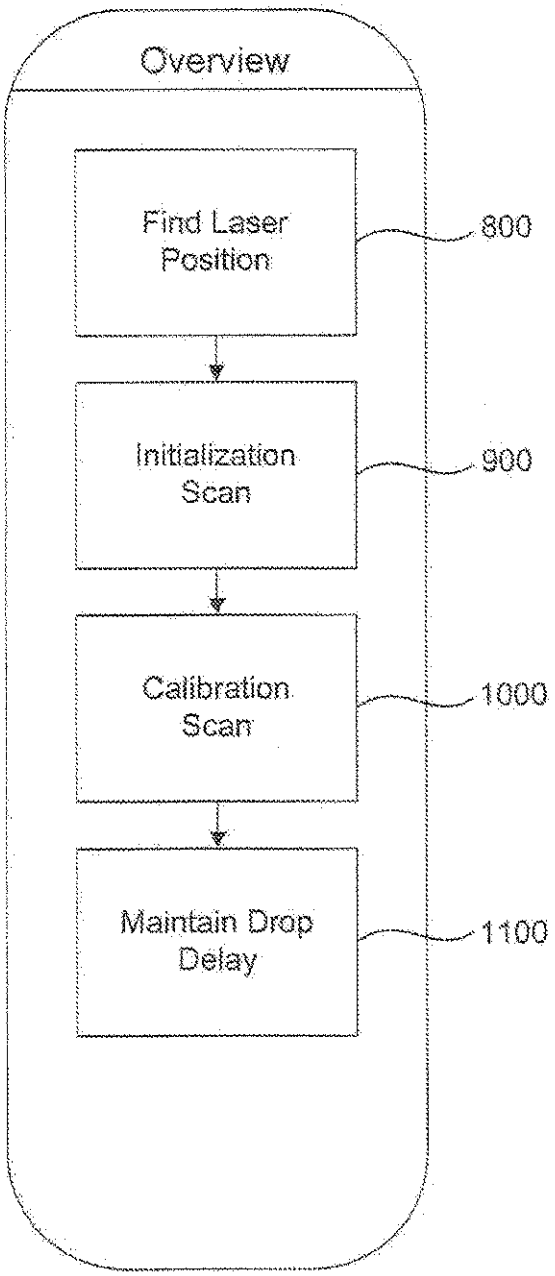

Overview
Find Laser Position
800
Initialization Scan
900
Calibration Scan
1000
Maintain Drop Delay
1100

FIG. 7

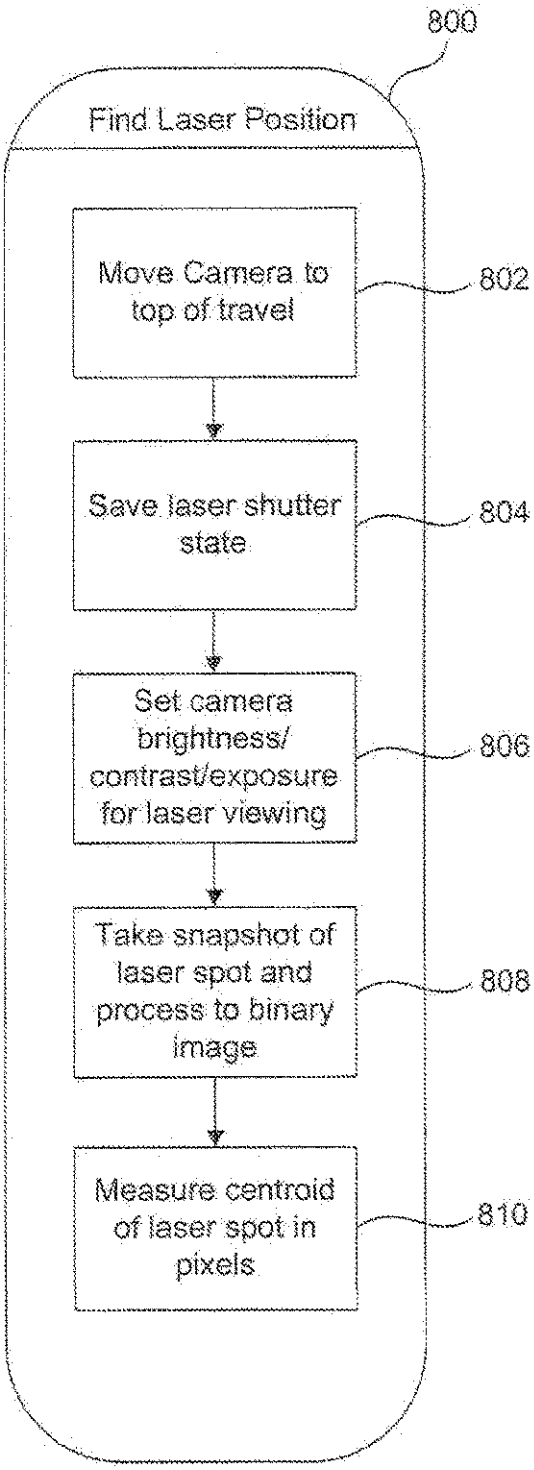

800
Find Laser Position
Move Camera to top of travel
802
Save laser shutter state
804
Set camera brightness/ contrast/exposure for laser viewing
806
Take snapshot of laser spot and process to binary image
808
Measure centroid of laser spot in pixels
810

FIG. 8

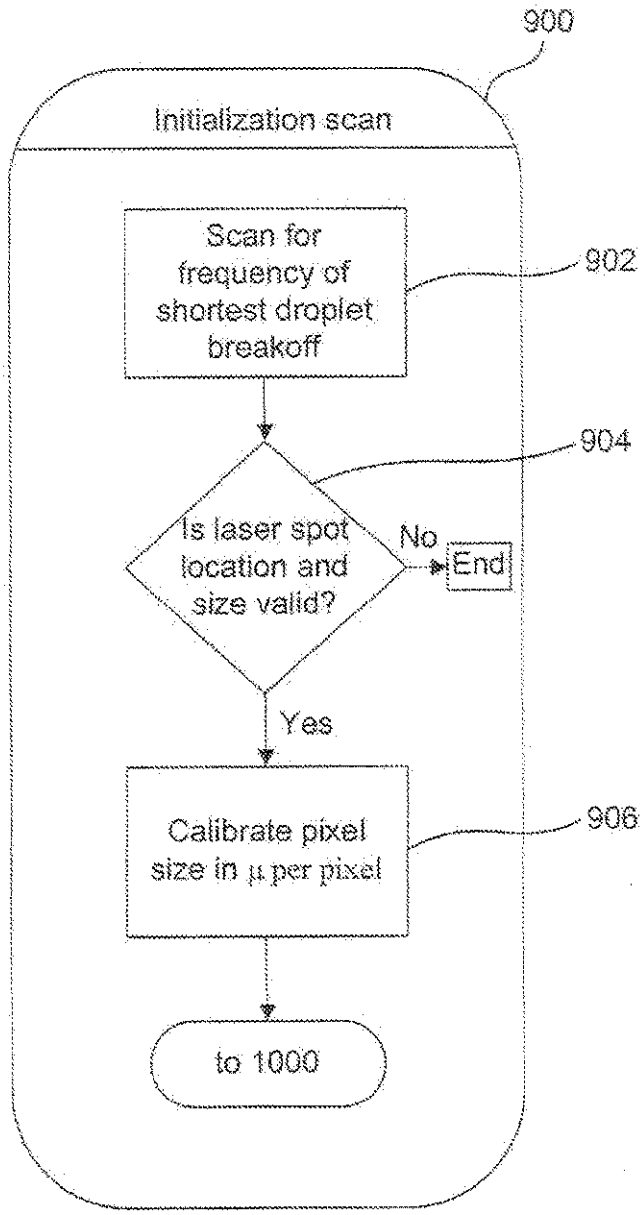

900
Initialization scan
Scan for frequency of shortest droplet breakoff
902
904
Is laser spot location and size valid?
No
End
Yes
Calibrate pixel size in μ per pixel
906
to 1000

FIG. 9A

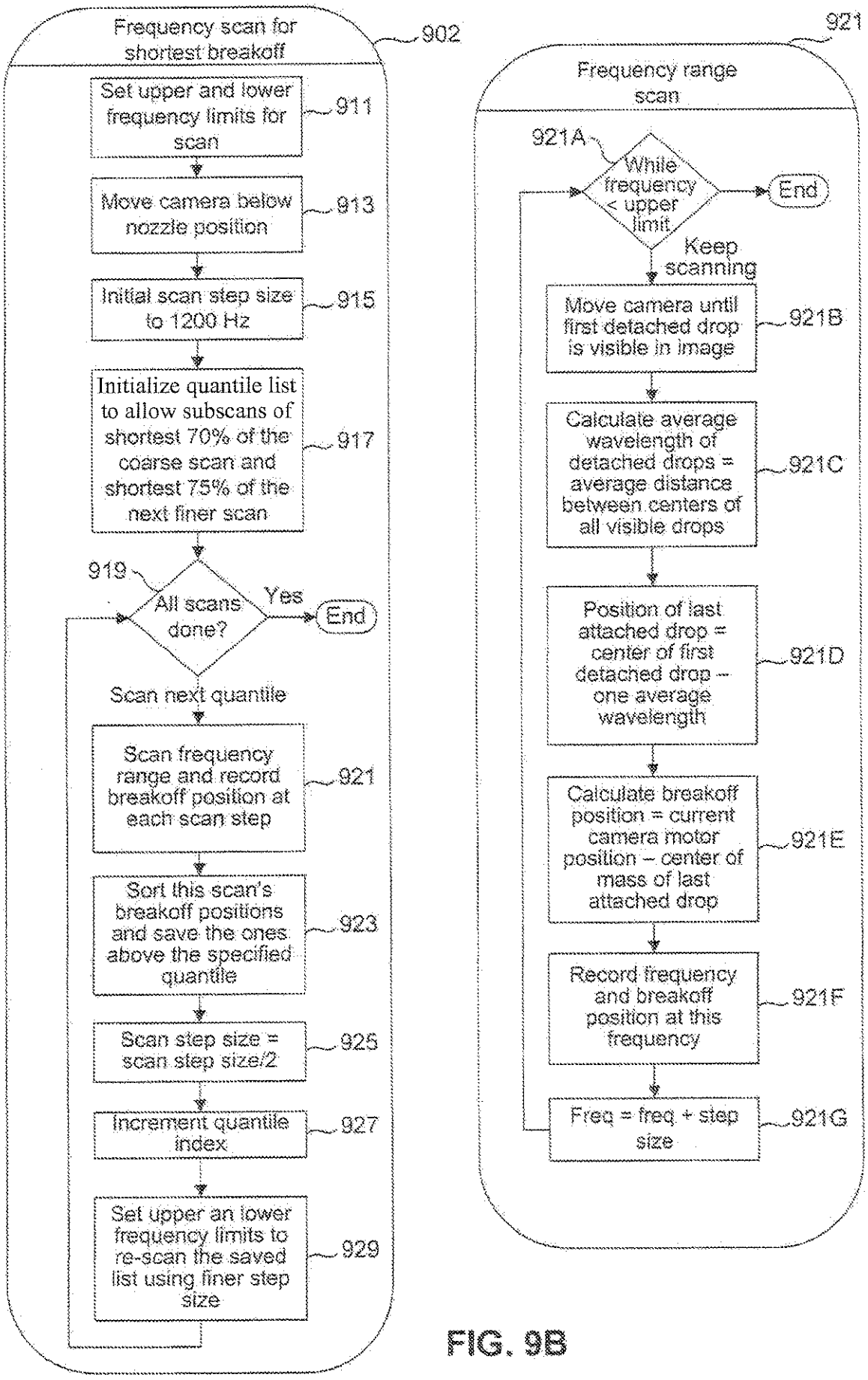

Frequency scan for shortest breakoff
902
Set upper and lower frequency limits for scan
911
Move camera below nozzle position
913
Initial scan step size to 1200 Hz
915
Initialize quantile list to allow subscans of shortest 70% of the coarse scan and shortest 75% of the next finer scan
917
919
All scans done?
Yes
End
Scan next quantile
Scan frequency range and record breakoff position at each scan step
921
Sort this scan's breakoff positions and save the ones above the specified quantile
923
Scan step size = scan step size/2
925
Increment quantile index
927
Set upper an lower frequency limits to re-scan the saved list using finer step size
929
921
Frequency range scan
921A
While frequency < upper limit
End
Keep scanning
Move camera until first detached drop is visible in image
921B
Calculate average wavelength of detached drops = average distance between centers of all visible drops
921C
Position of last attached drop = center of first detached drop – one average wavelength
921D
Calculate breakoff position = current camera motor position – center of mass of last attached drop
921E
Record frequency and breakoff position at this frequency
921F
Freq = freq + step size
921G

FIG. 9B

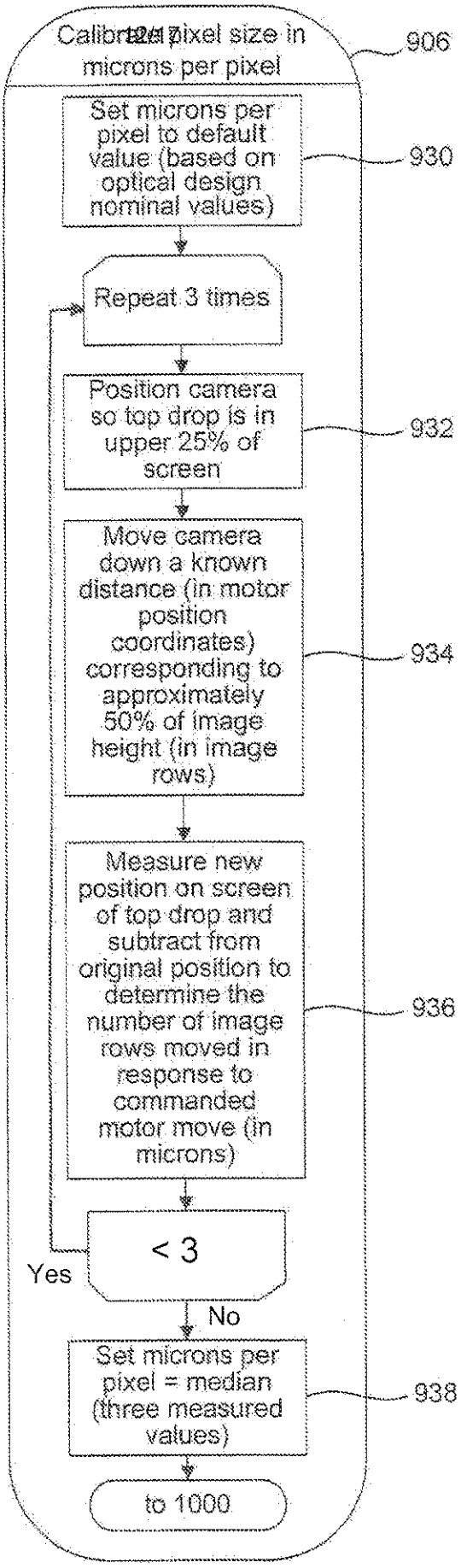

Calibrate pixel size in microns per pixel
906
Set microns per pixel to default value (based on optical design nominal values)
930
Repeat 3 times
Position camera so top drop is in upper 25% of screen
932
Move camera down a known distance (in motor position coordinates) corresponding to approximately 50% of image height (in image rows)
934
Measure new position on screen of top drop and subtract from original position to determine the number of image rows moved in response to commanded motor move (in microns)
936
< 3
Yes
No
Set microns per pixel = median (three measured values)
938
to 1000

FIG. 9C

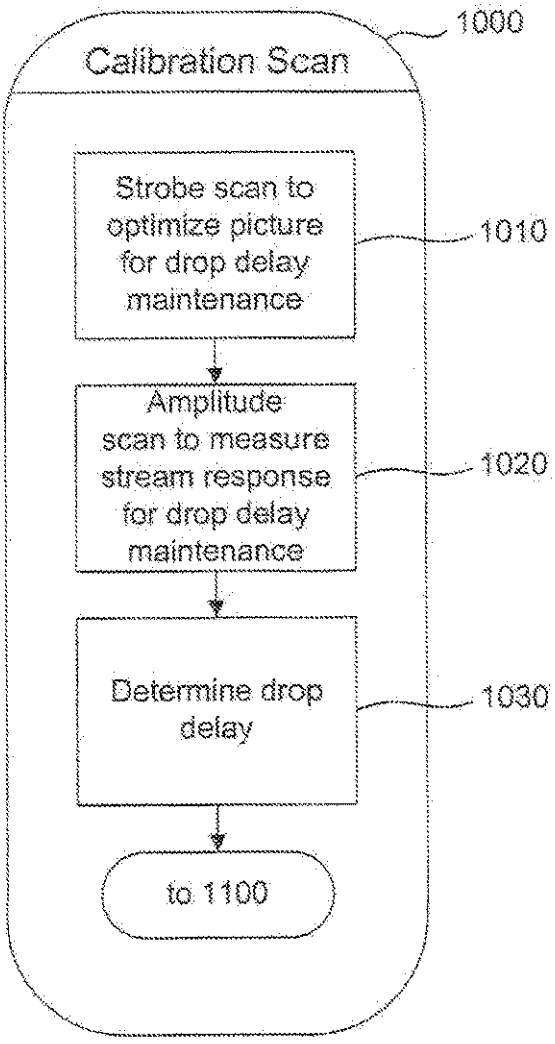

1000
Calibration Scan
Strobe scan to optimize picture for drop delay maintenance
1010
Amplitude scan to measure stream response for drop delay maintenance
1020
Determine drop delay
1030
to 1100

FIG. 10A

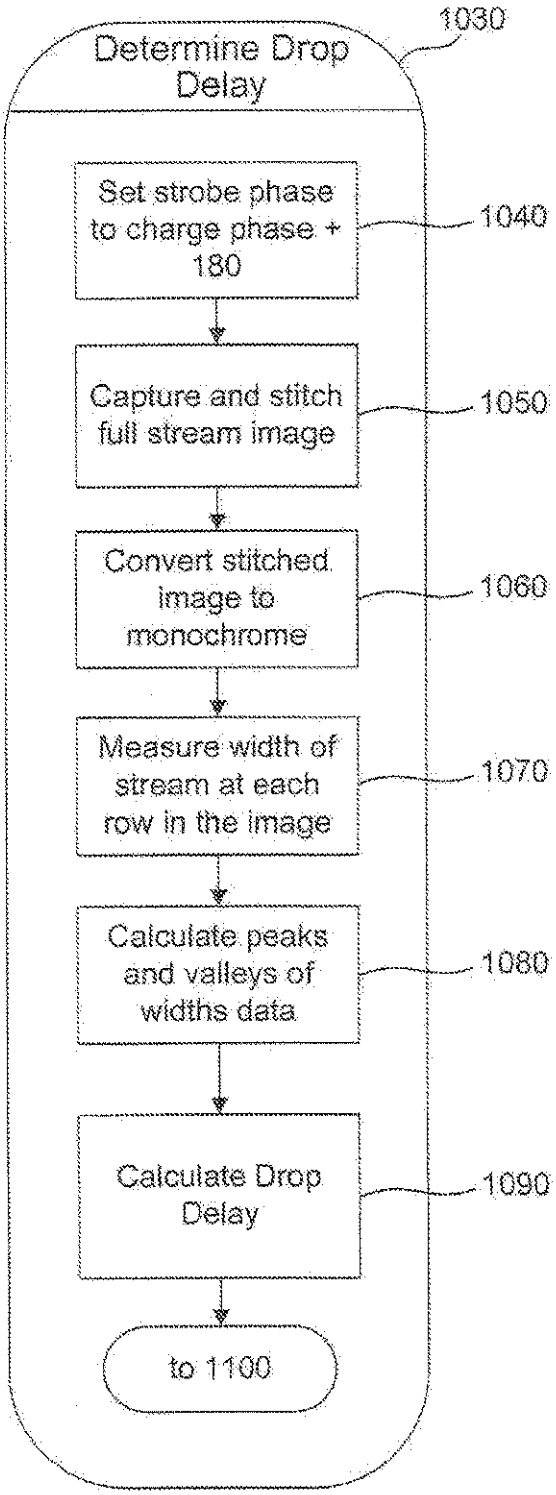

Determine Drop Delay
1030
Set strobe phase to charge phase + 180
1040
Capture and stitch full stream image
1050
Convert stitched image to monochrome
1060
Measure width of stream at each row in the image
1070
Calculate peaks and valleys of widths data
1080
Calculate Drop Delay
1090
to 1100

FIG. 10B

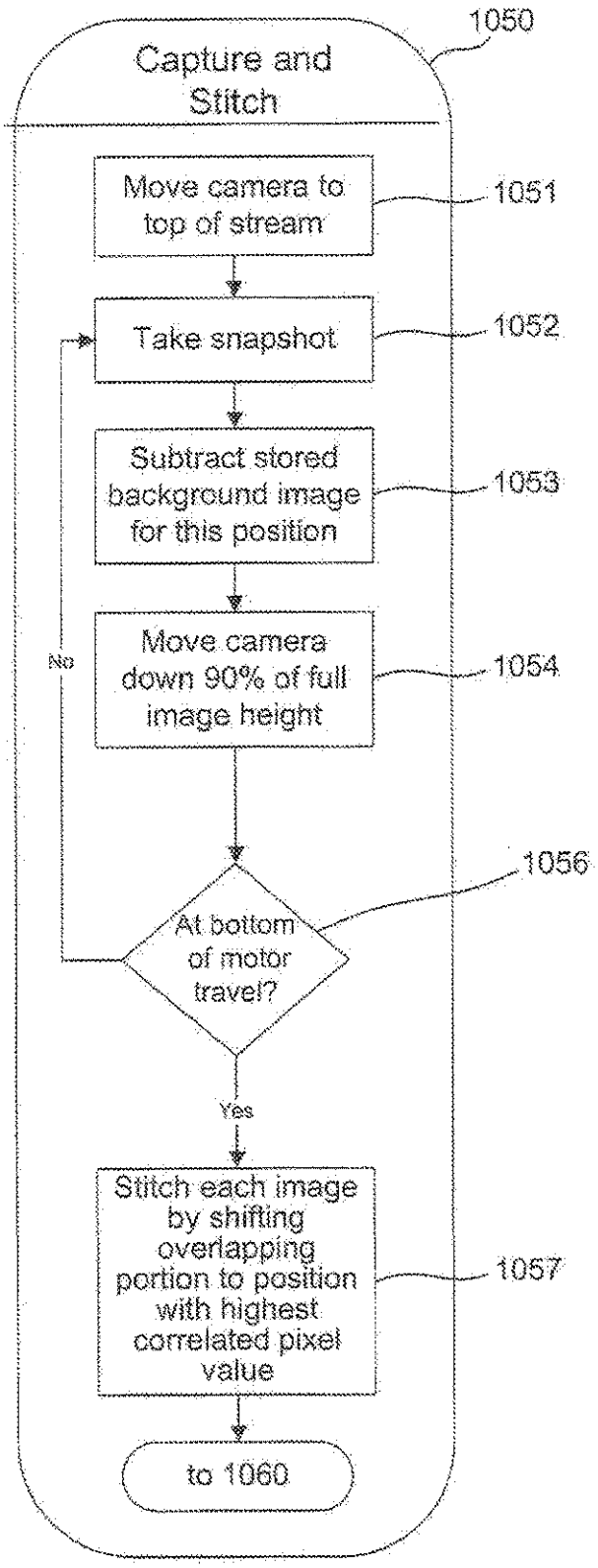

1050
Capture and Stitch
Move camera to top of stream
1051
Take snapshot
1052
Subtract stored background image for this position
1053
Move camera down 90% of full image height
1054
No
At bottom of motor travel?
1056
Yes
Stitch each image by shifting overlapping portion to position with highest correlated pixel value
1057
to 1060

FIG. 10C

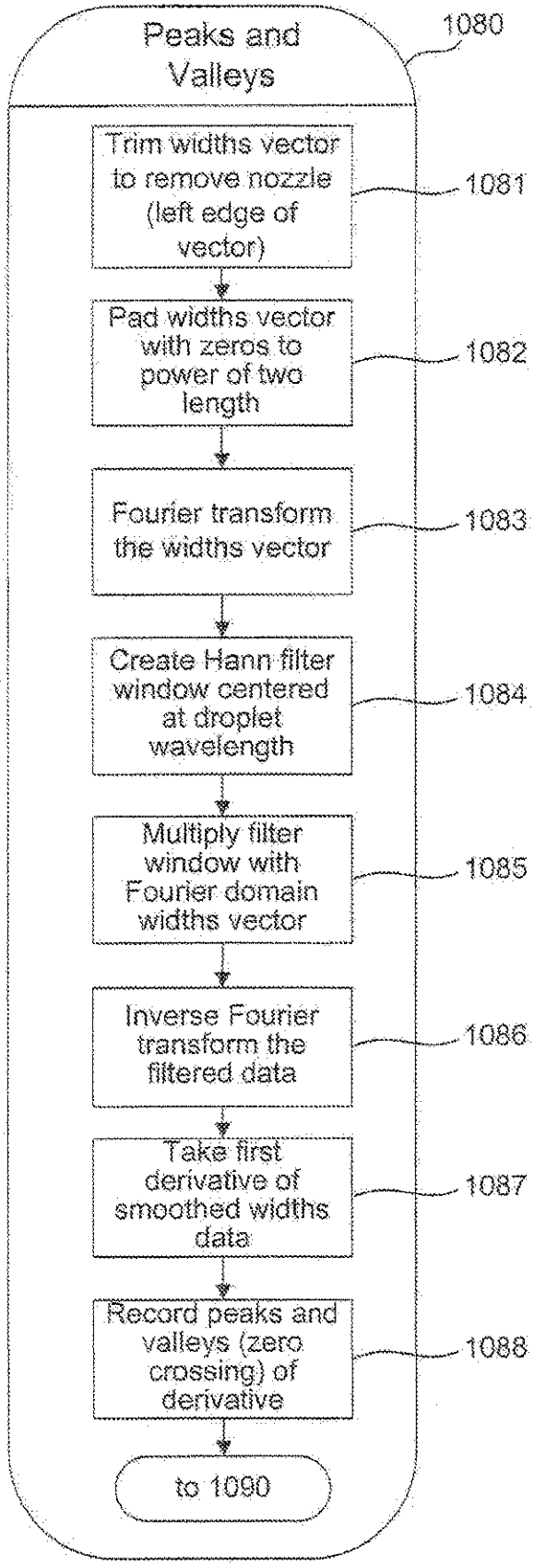

Peaks and Valleys
1080
Trim widths vector to remove nozzle (left edge of vector)
1081
Pad widths vector with zeros to power of two length
1082
Fourier transform the widths vector
1083
Create Hann filter window centered at droplet wavelength
1084
Multiply filter window with Fourier domain widths vector
1085
Inverse Fourier transform the filtered data
1086
Take first derivative of smoothed widths data
1087
Record peaks and valleys (zero crossing) of derivative
1088
to 1090

FIG. 10D

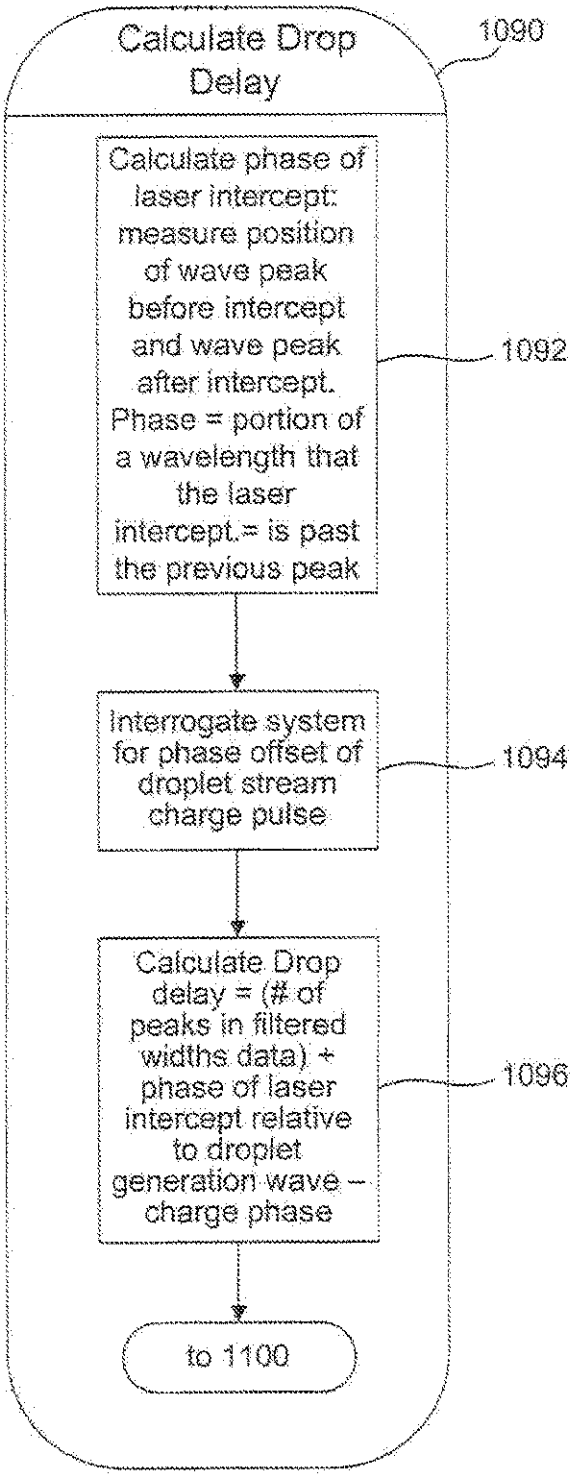

Calculate Drop Delay
1090
Calculate phase of laser intercept: measure position of wave peak before intercept and wave peak after intercept. Phase = portion of a wavelength that the laser intercept.= is past the previous peak
1092
Interrogate system for phase offset of droplet stream charge pulse
1094
Calculate Drop delay = (# of peaks in filtered widths data) + phase of laser intercept relative to droplet generation wave – charge phase
1096
to 1100

FIG. 10E