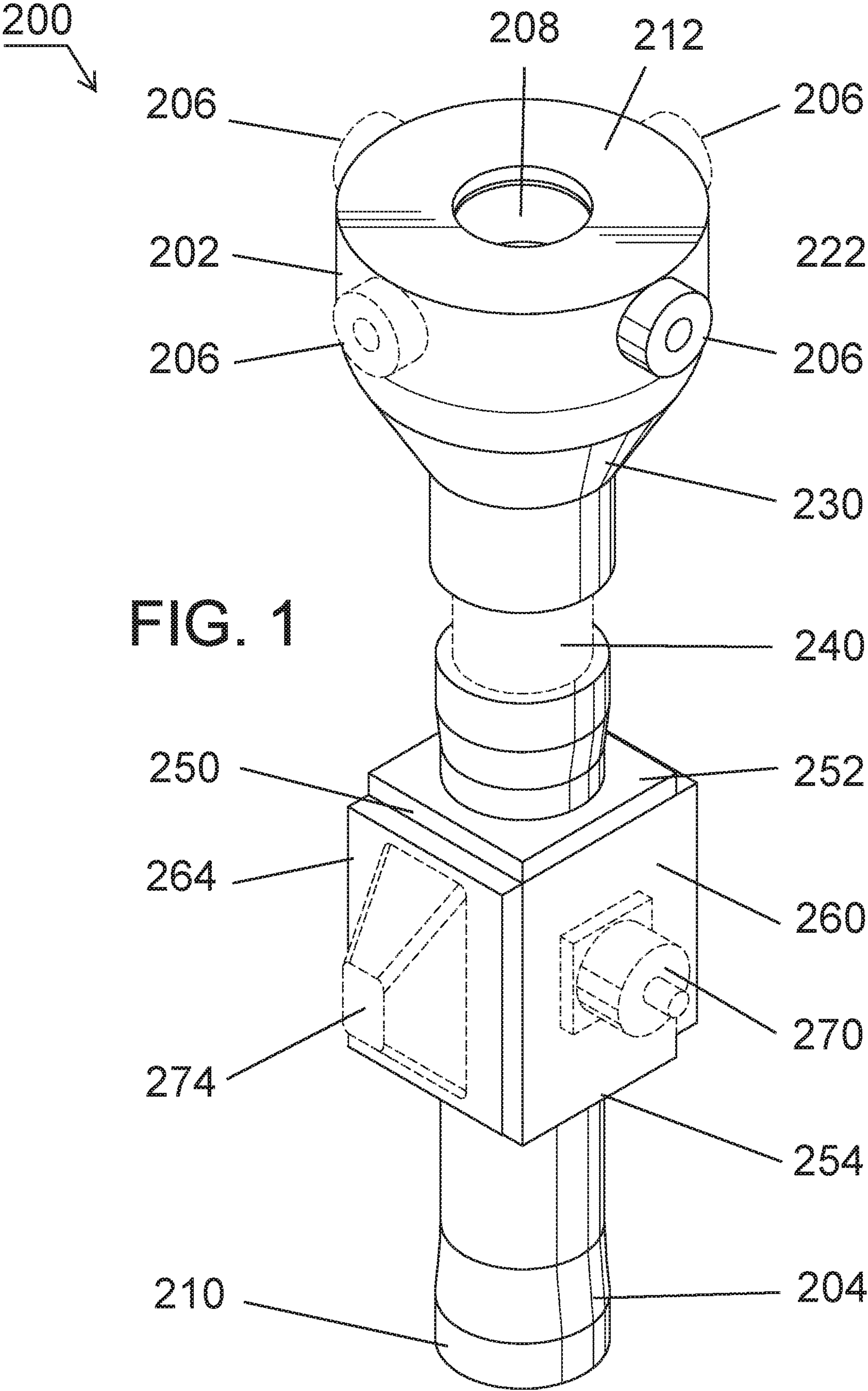
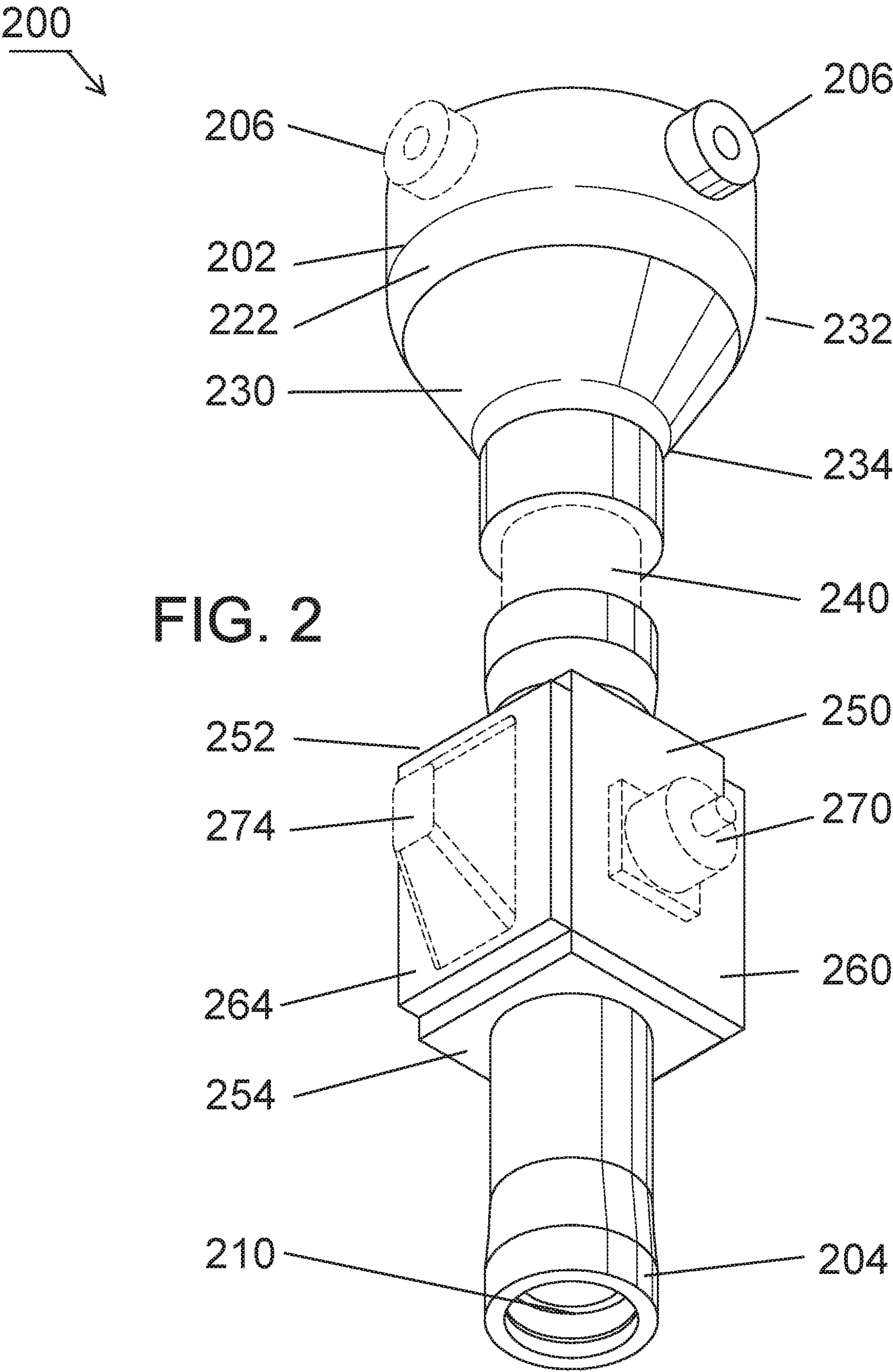






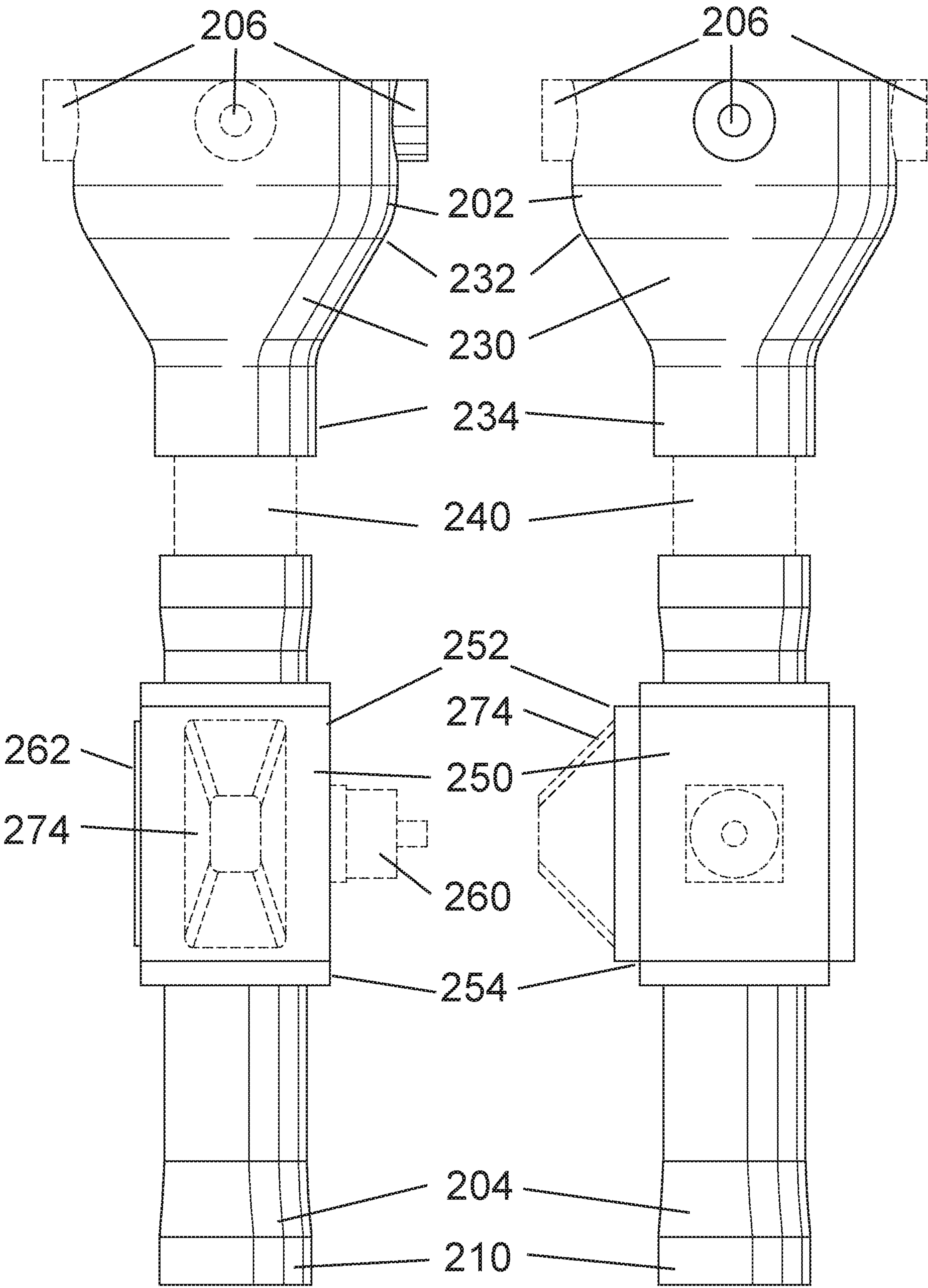


FIG. 3

FIG. 4

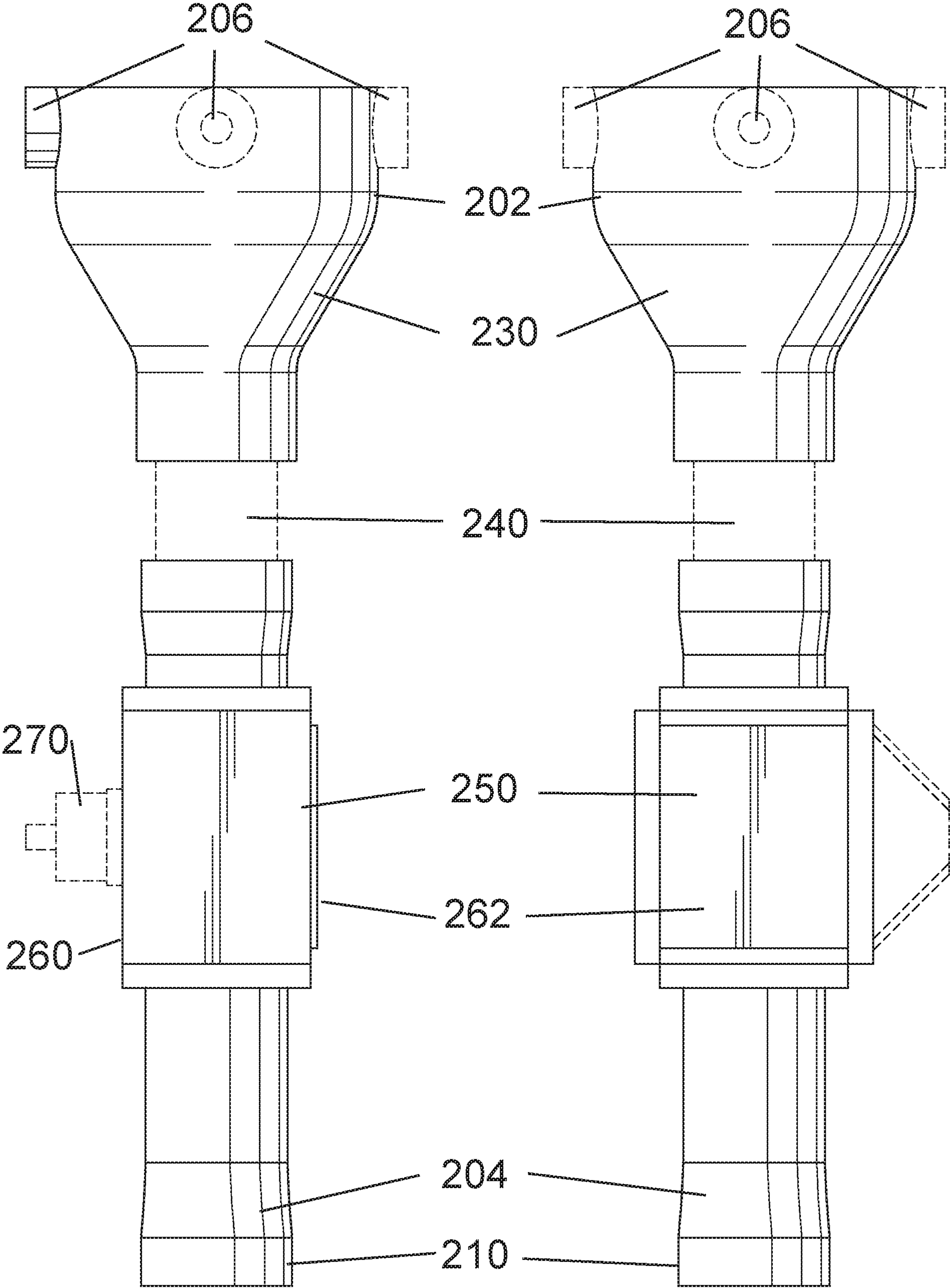


FIG. 6

FIG. 5

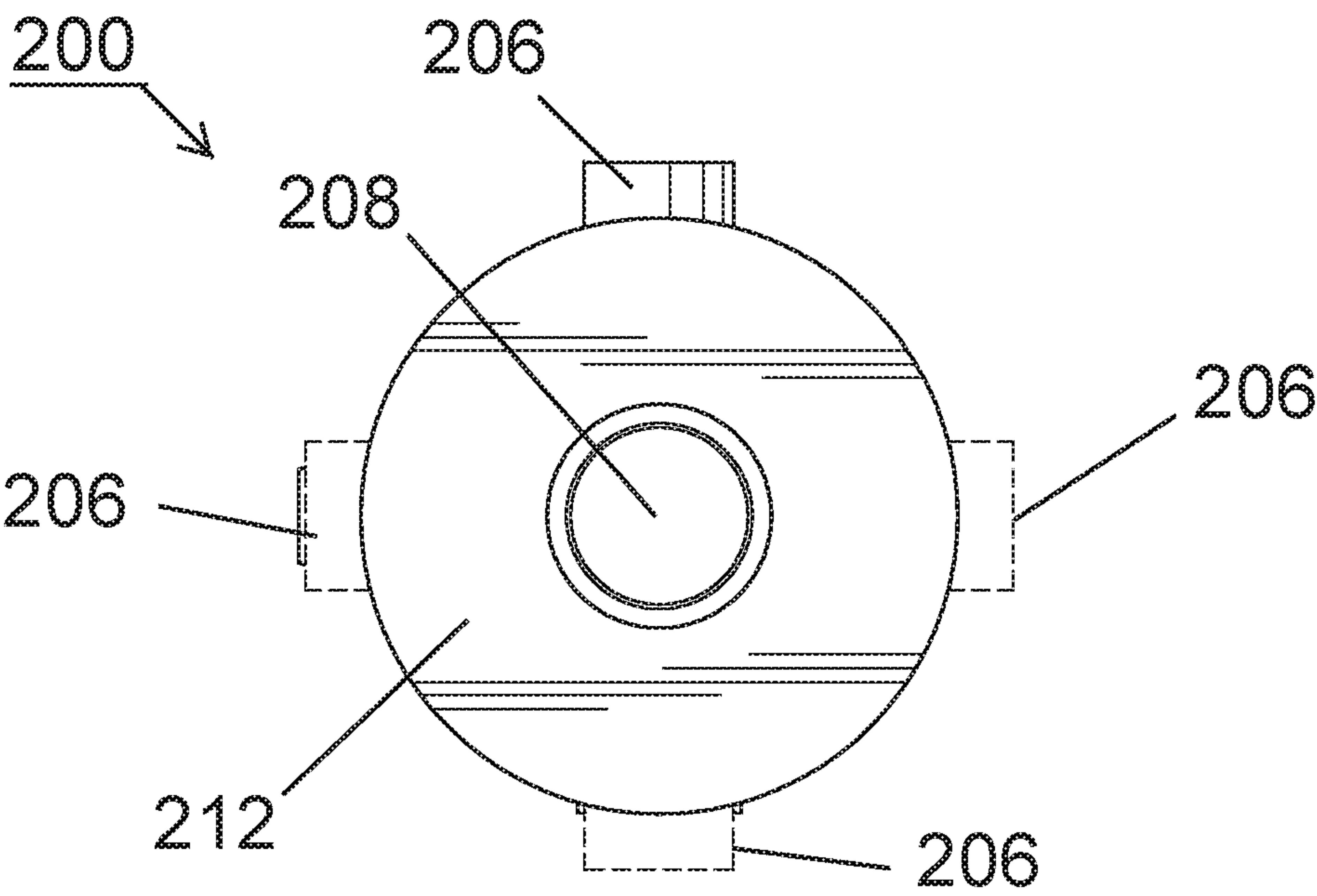


FIG. 7

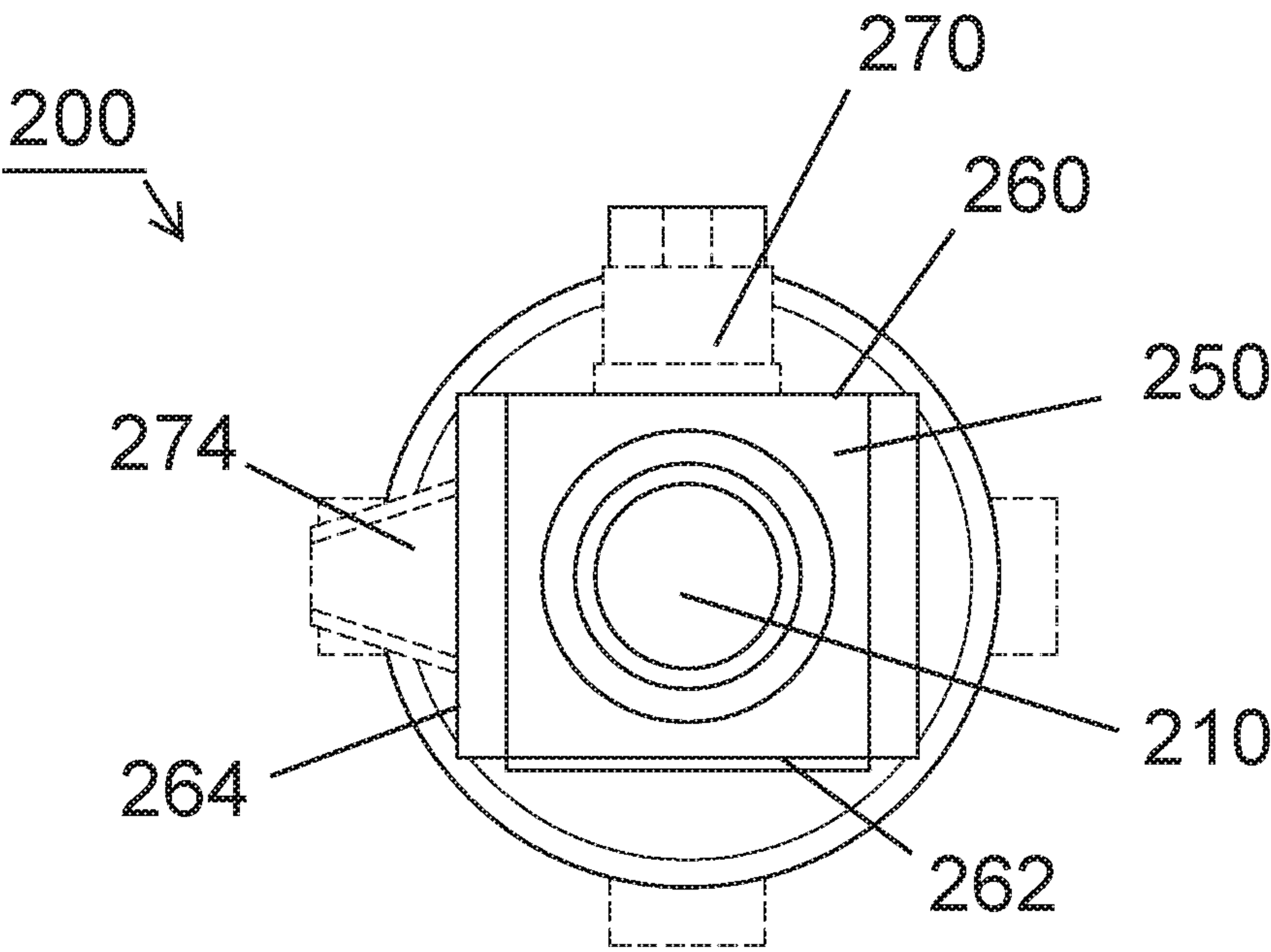
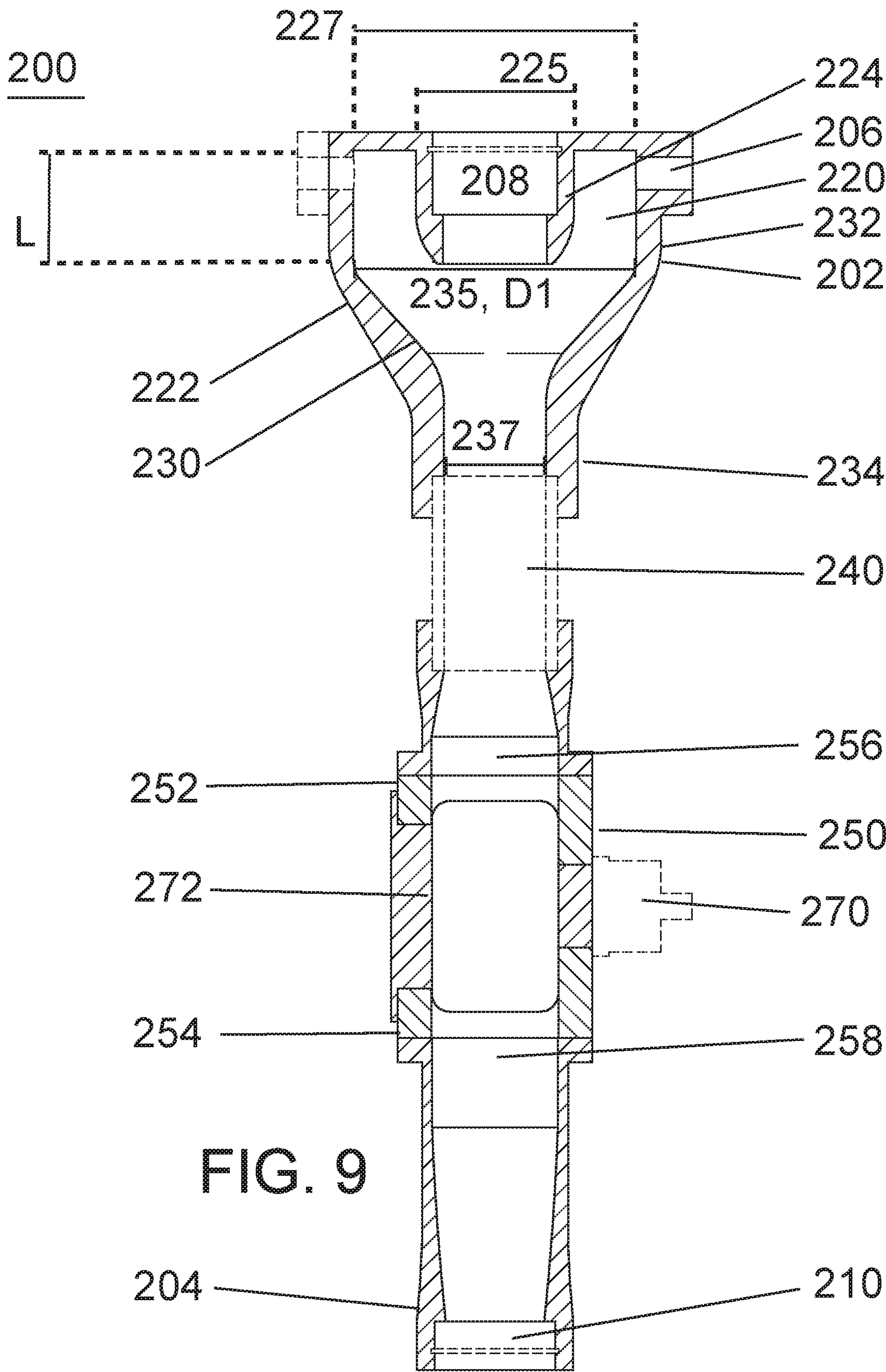


FIG. 8



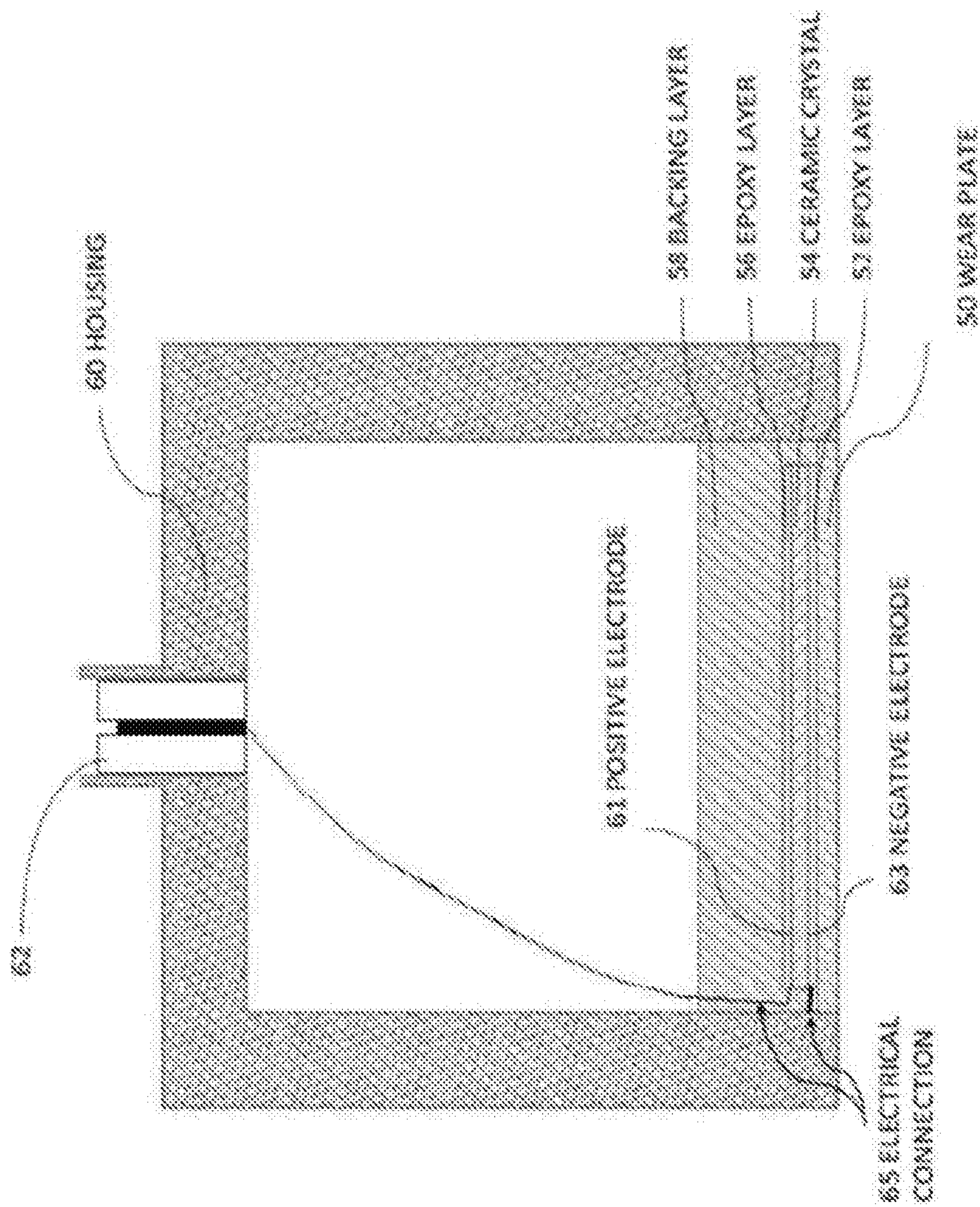


FIG. 10

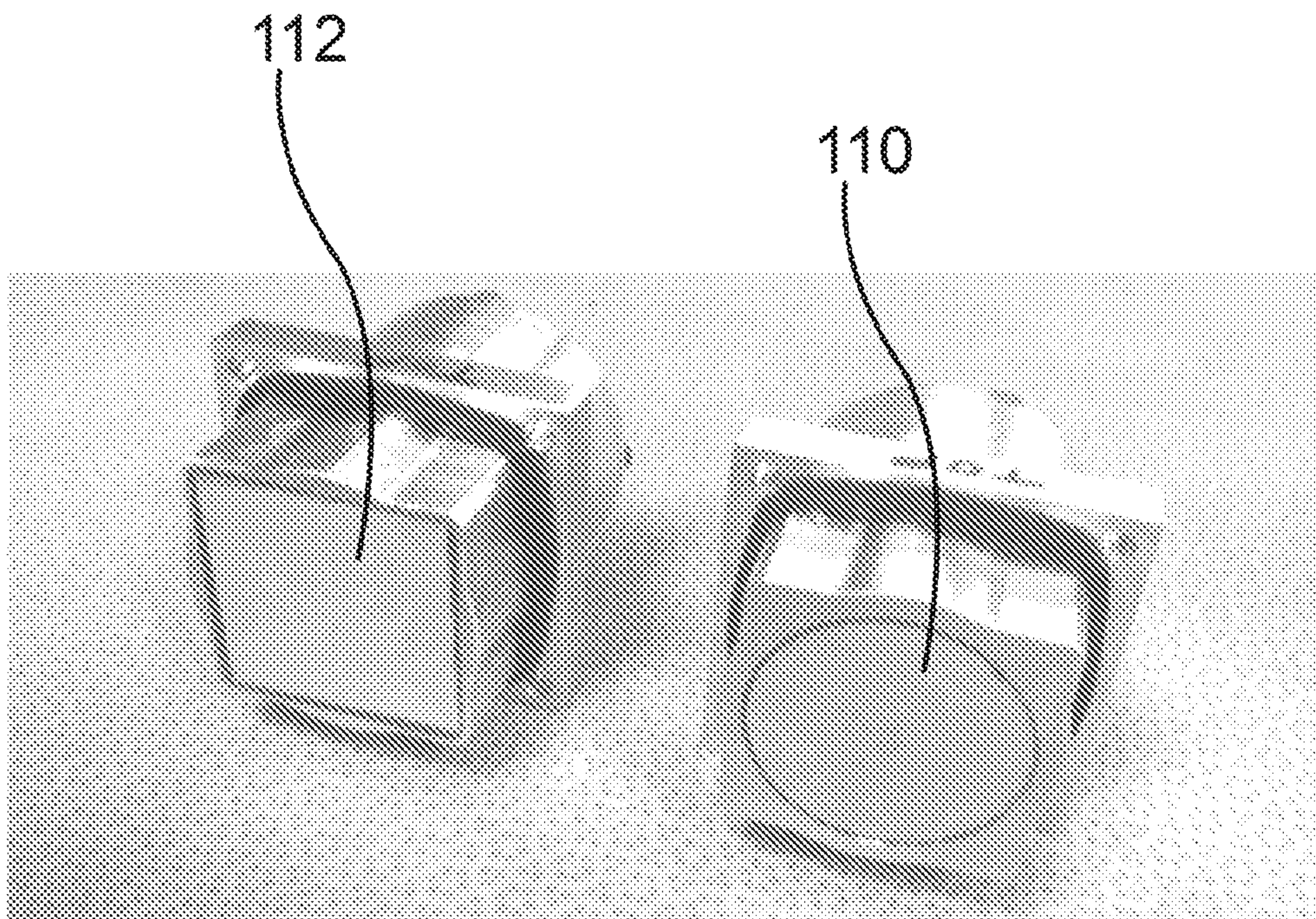


FIG. 12

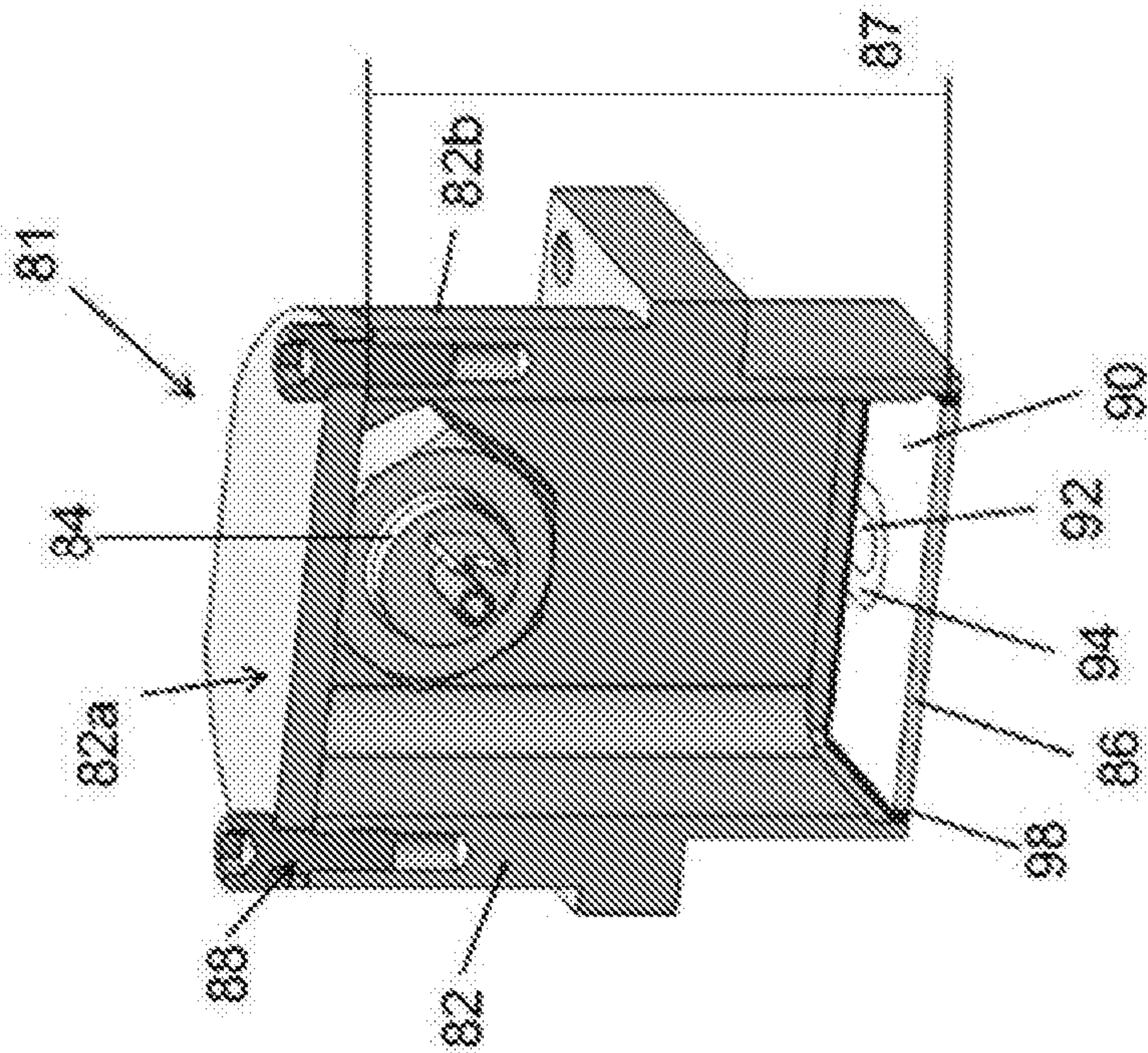
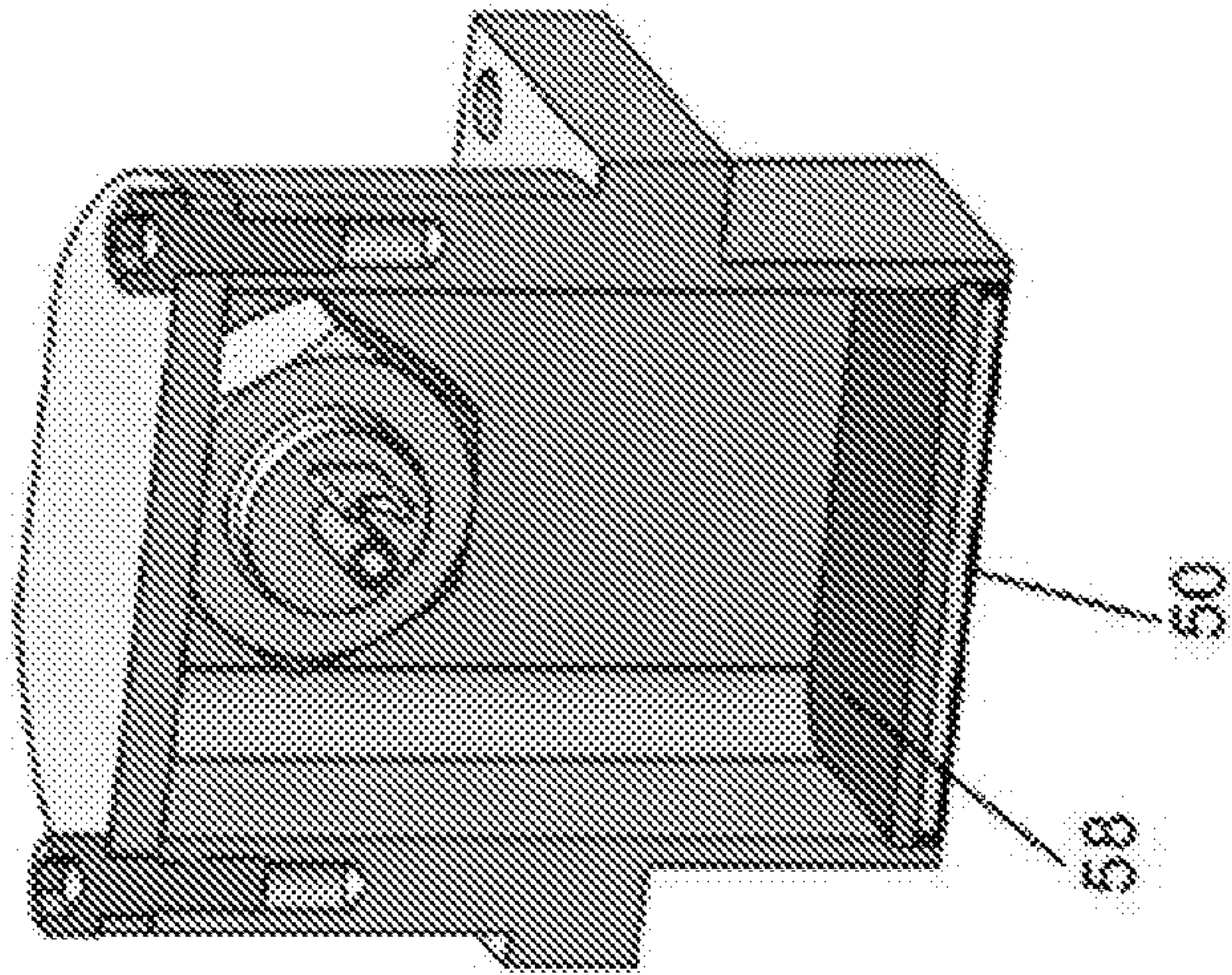


FIG. 11B



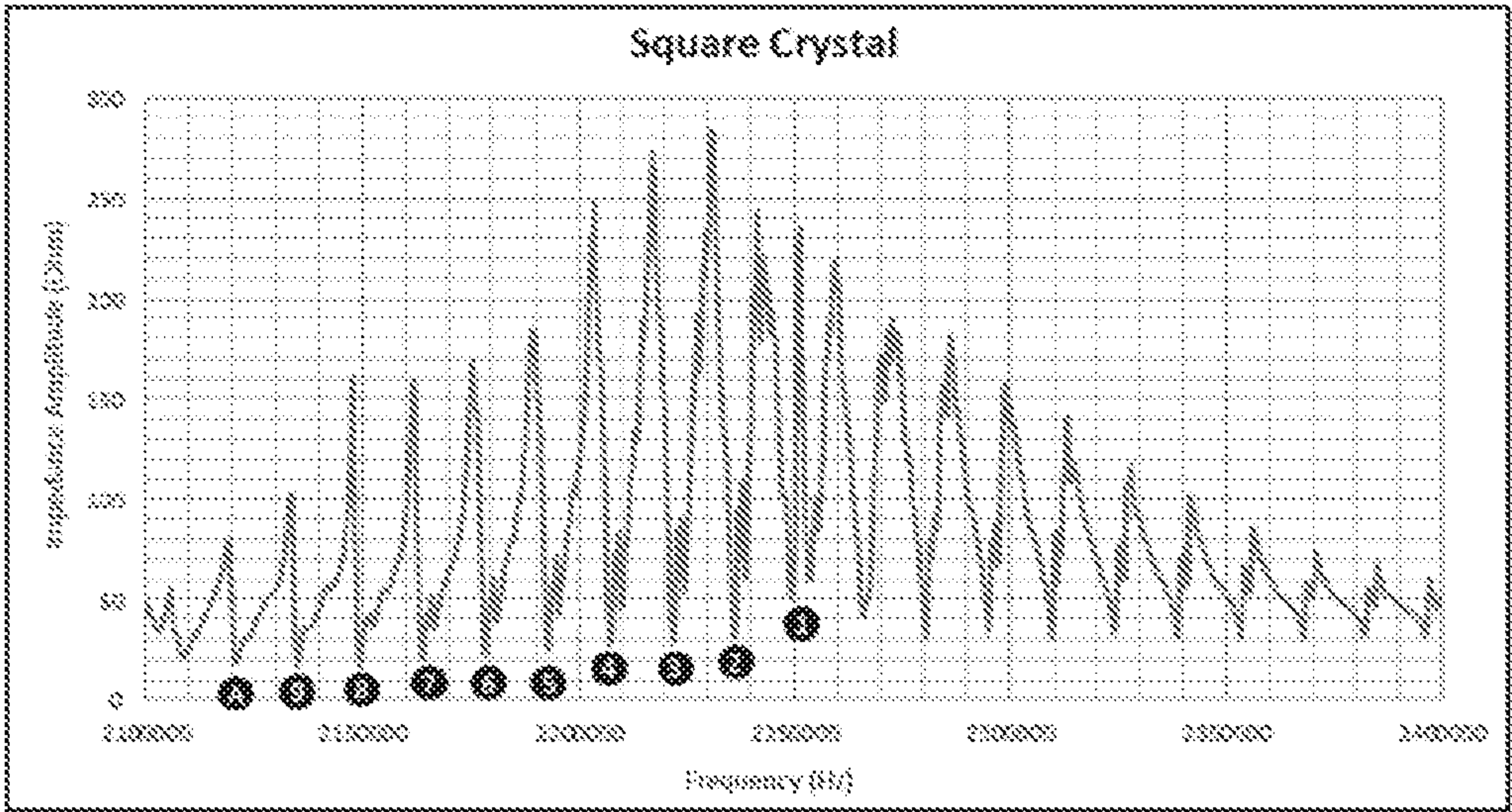


FIG. 13

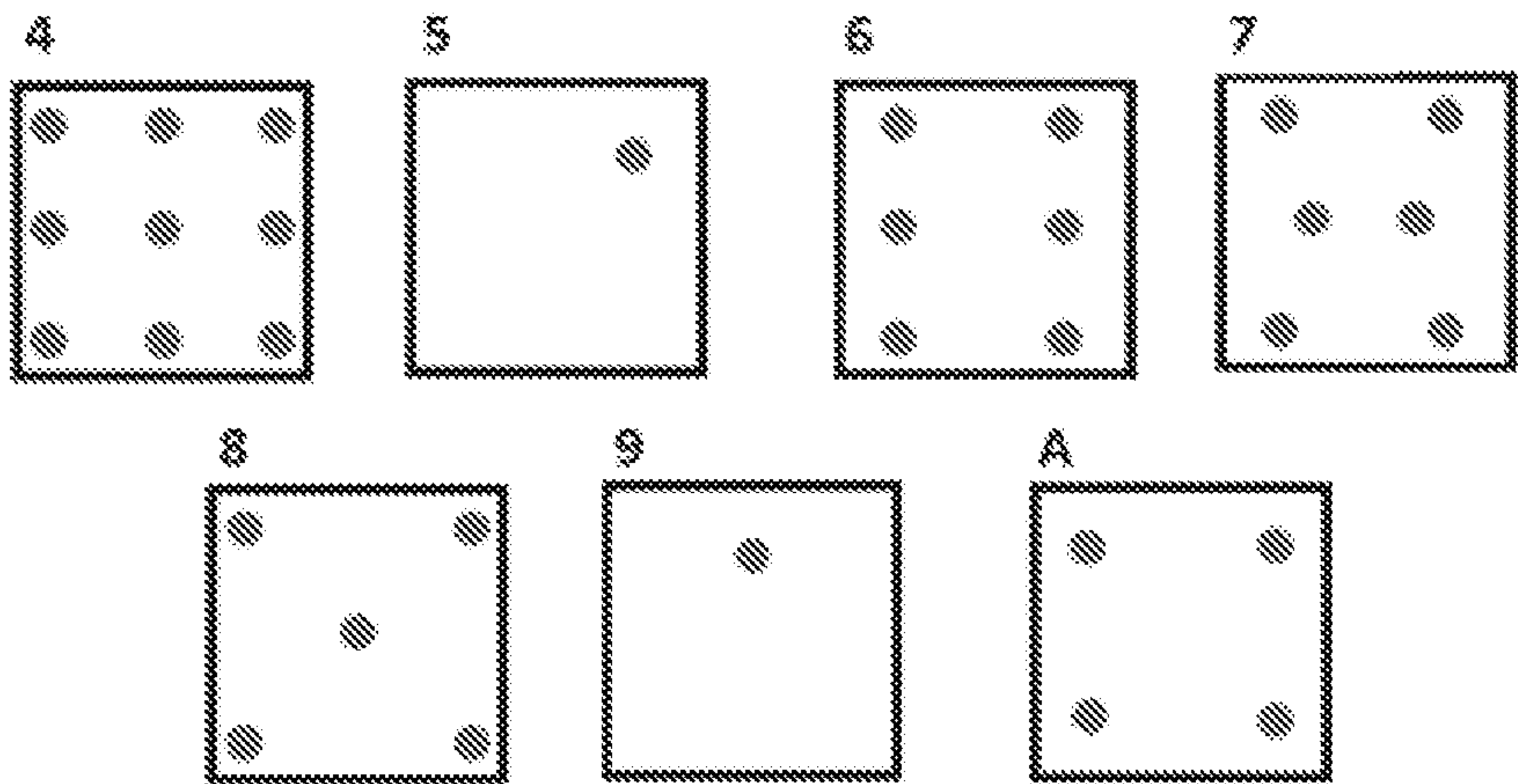


FIG. 14

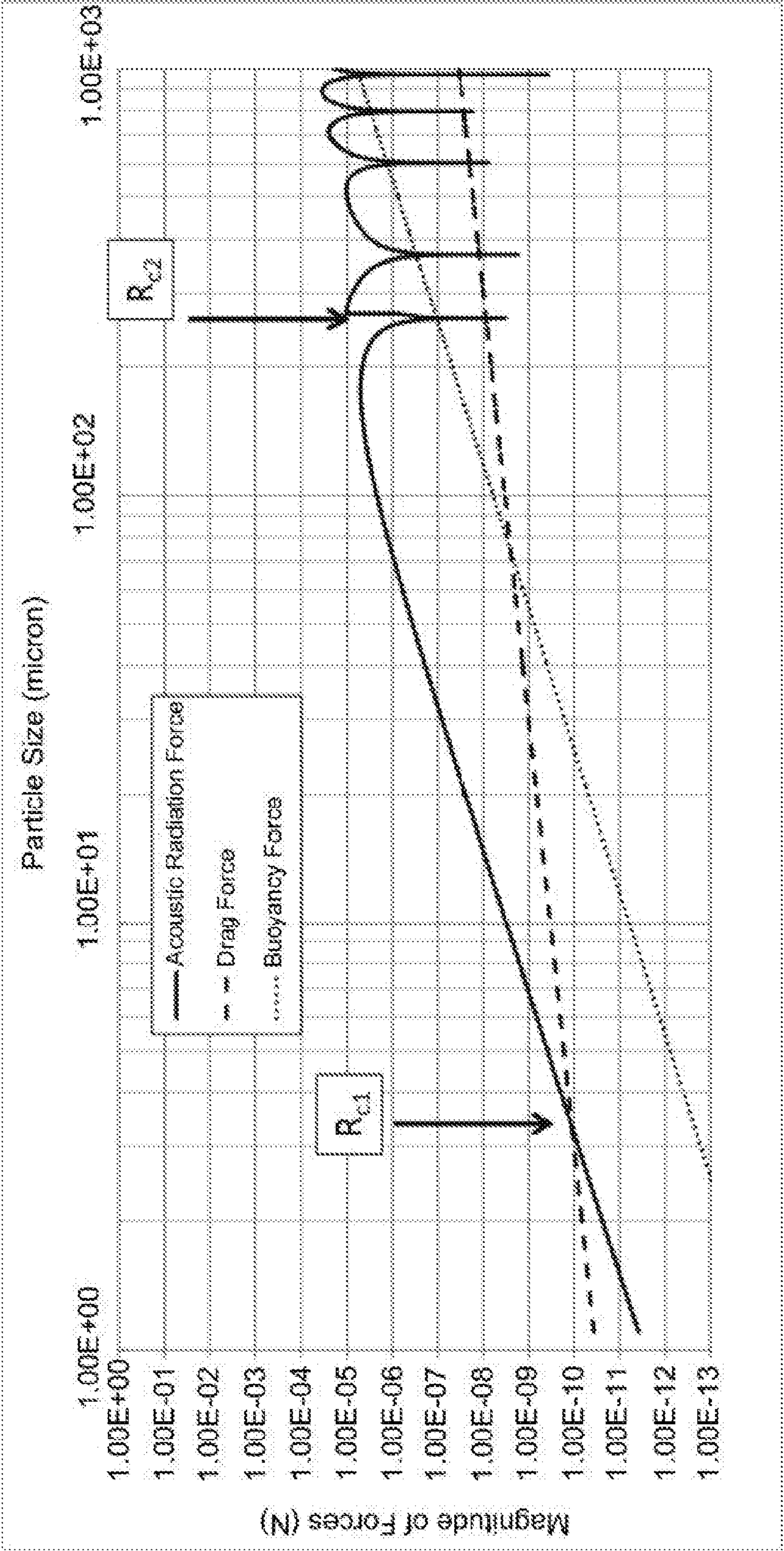


FIG. 13A

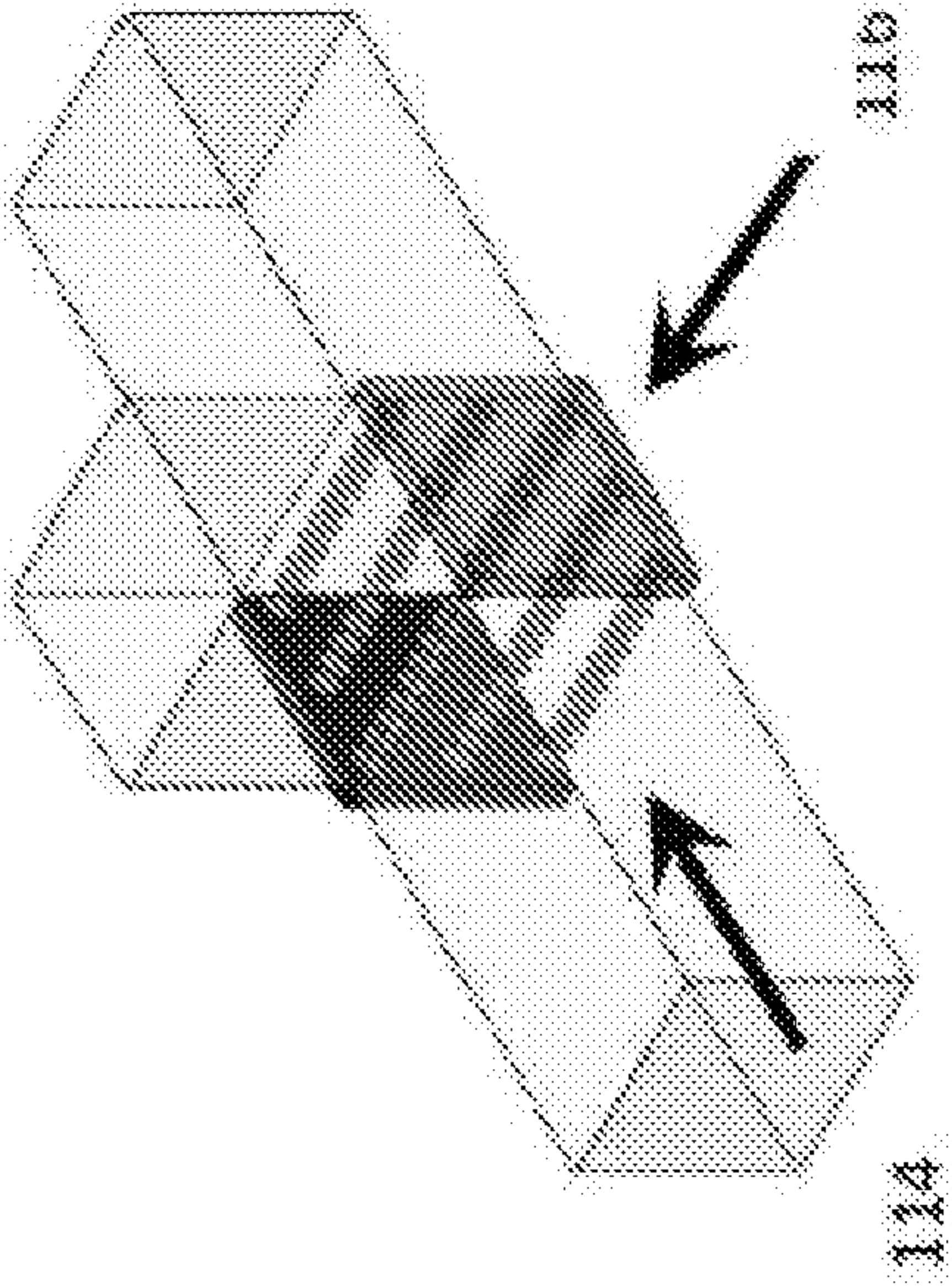


FIG. 14A

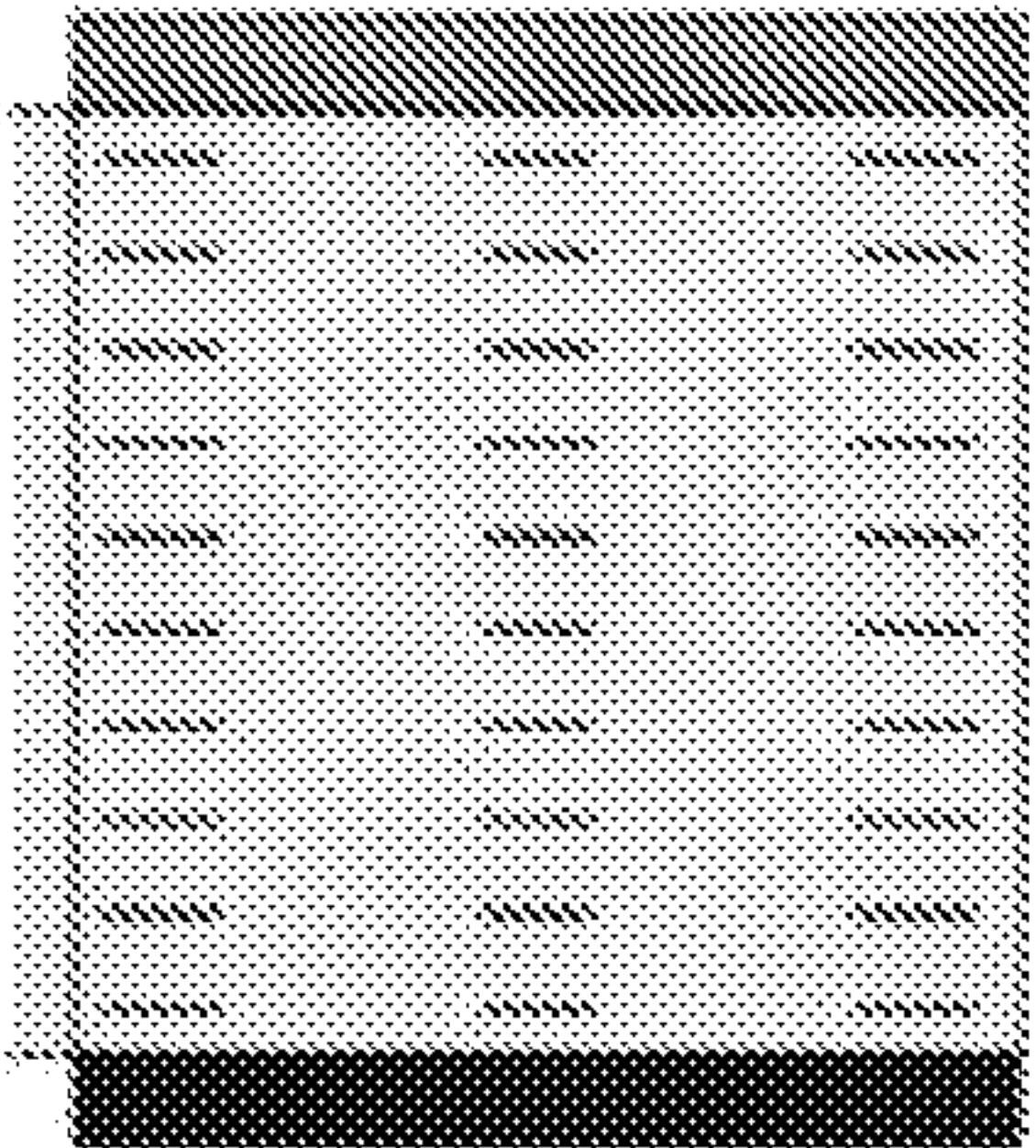


FIG. 14B

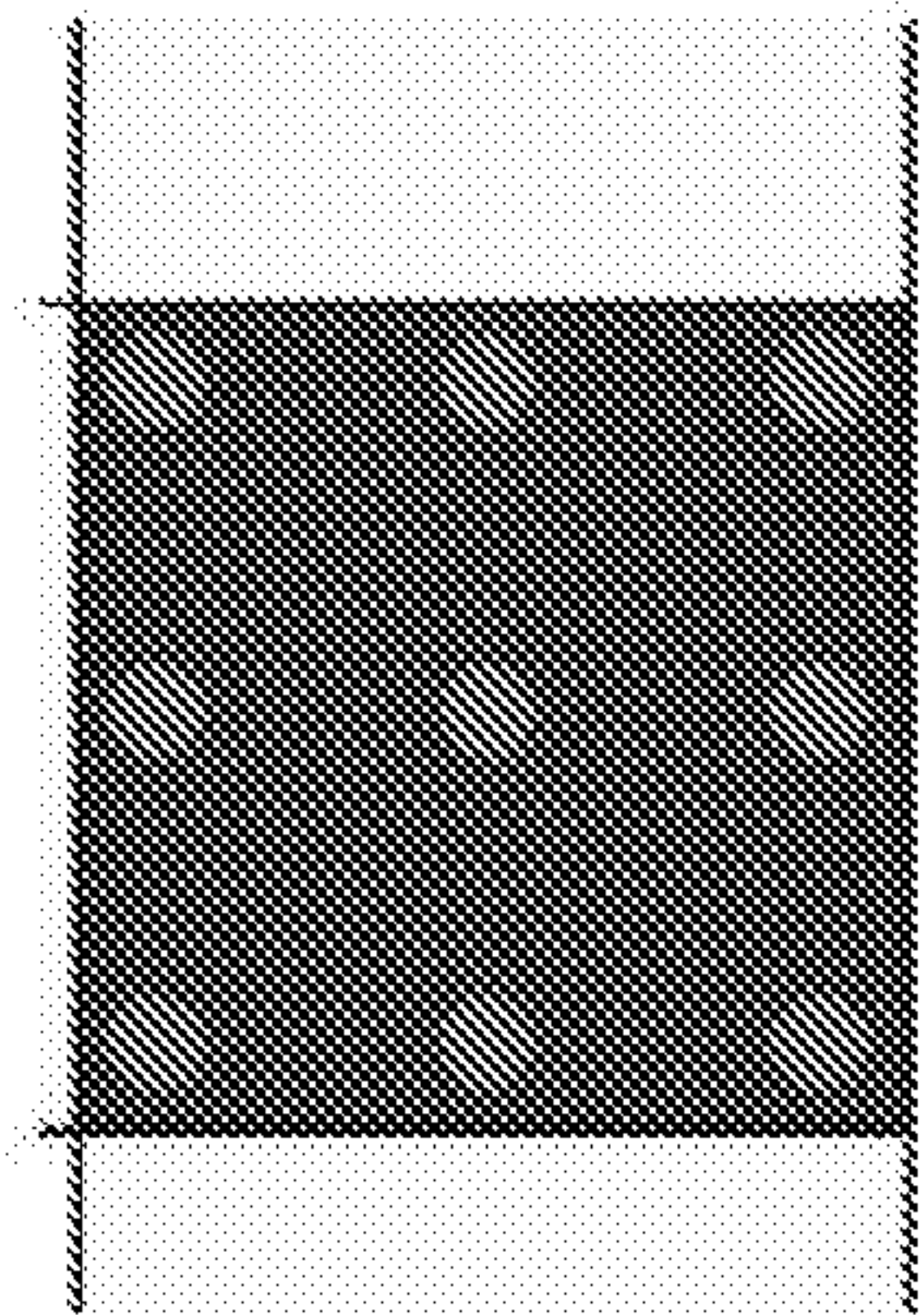


FIG. 14C

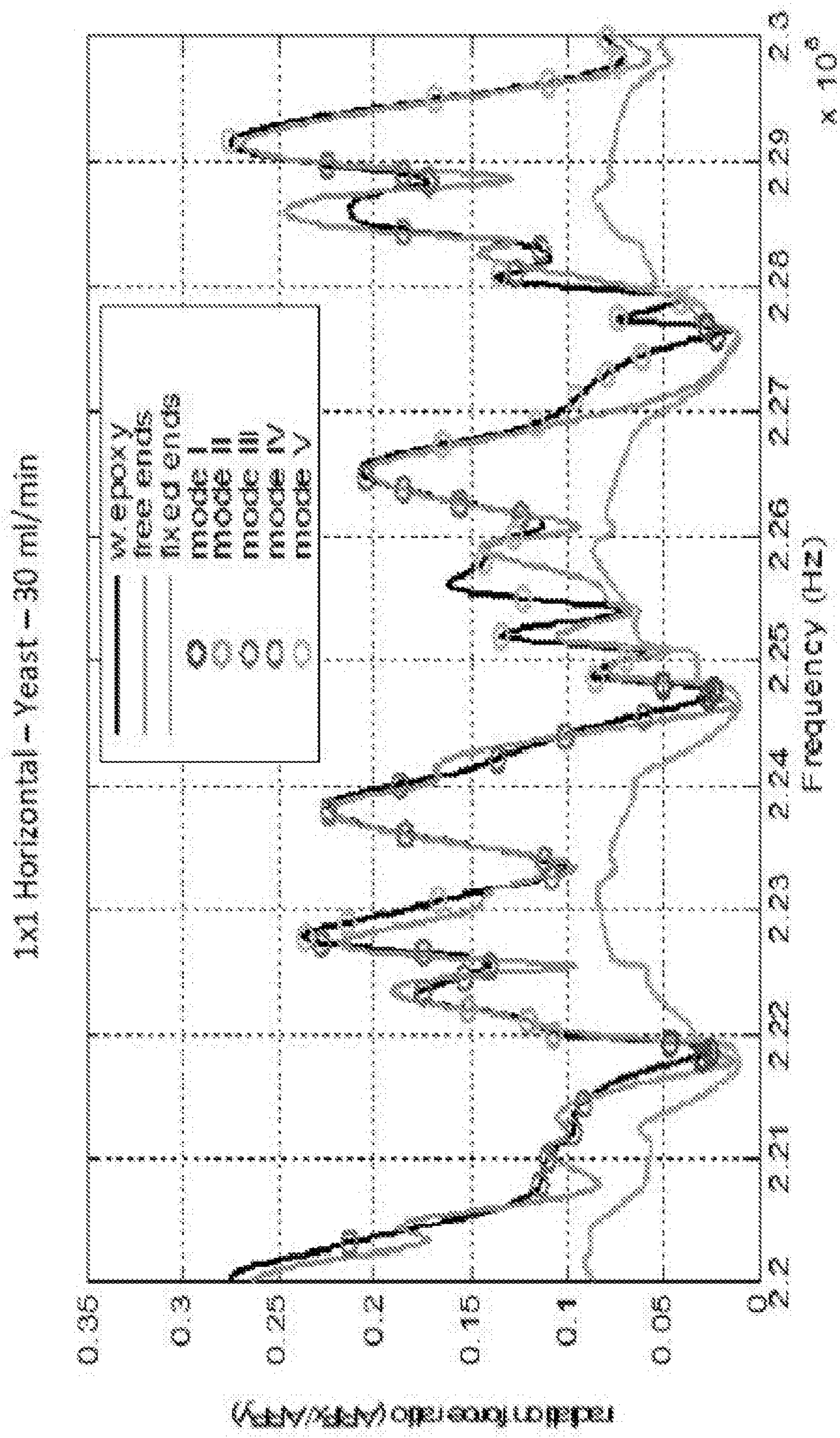


FIG. 31

- ※ Use of current source to drive the crystal
 - ※ Enhanced performance for the specific application
- ※ Use of VI-sensing to control the frequency and delivered power:
 - ※ Optimize performance
 - ※ Detect Degradation

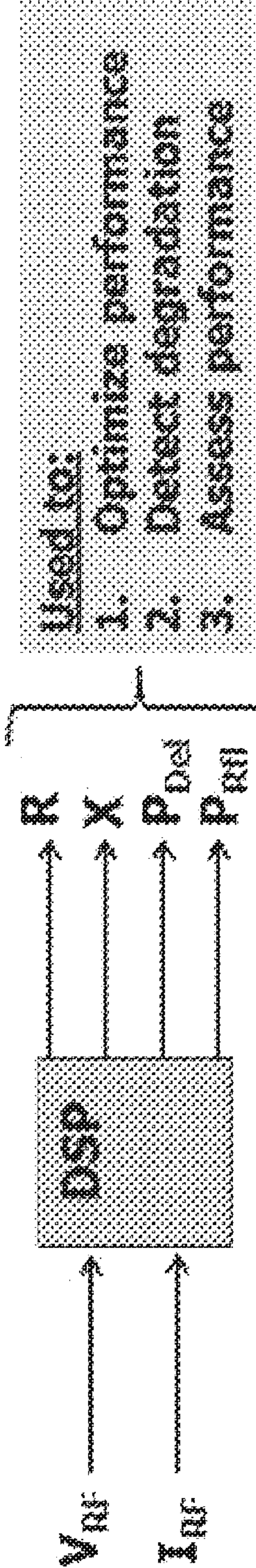
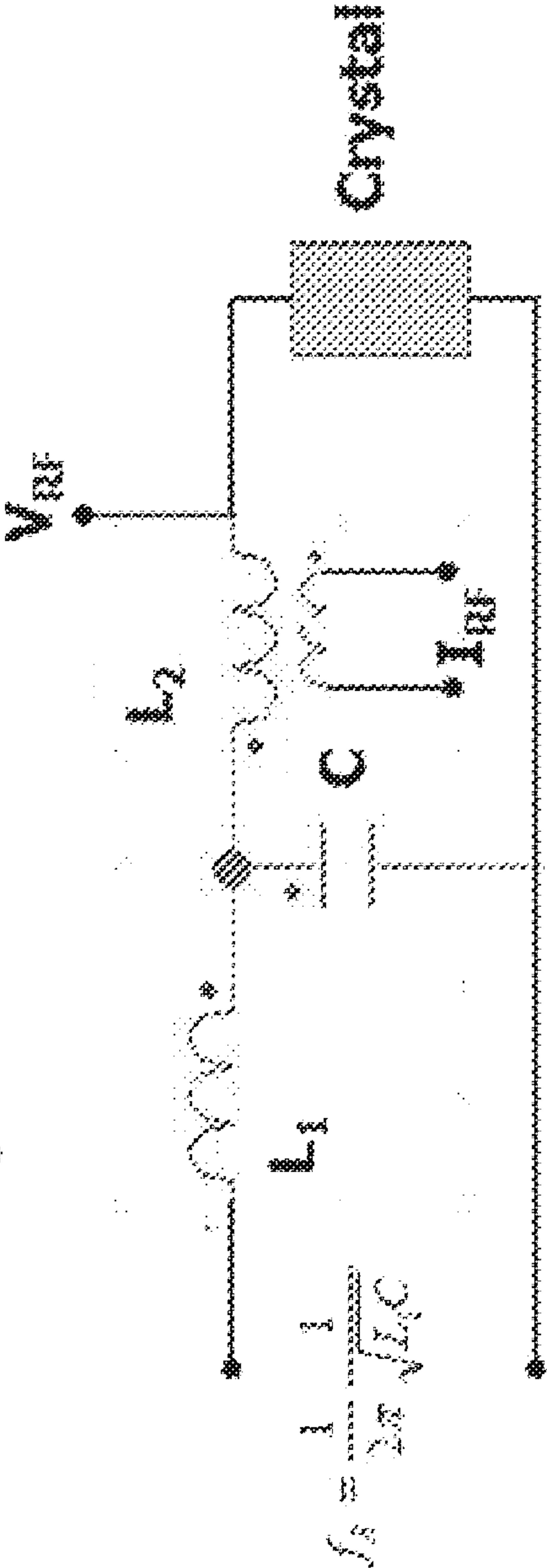


FIG. 32

Use of current source

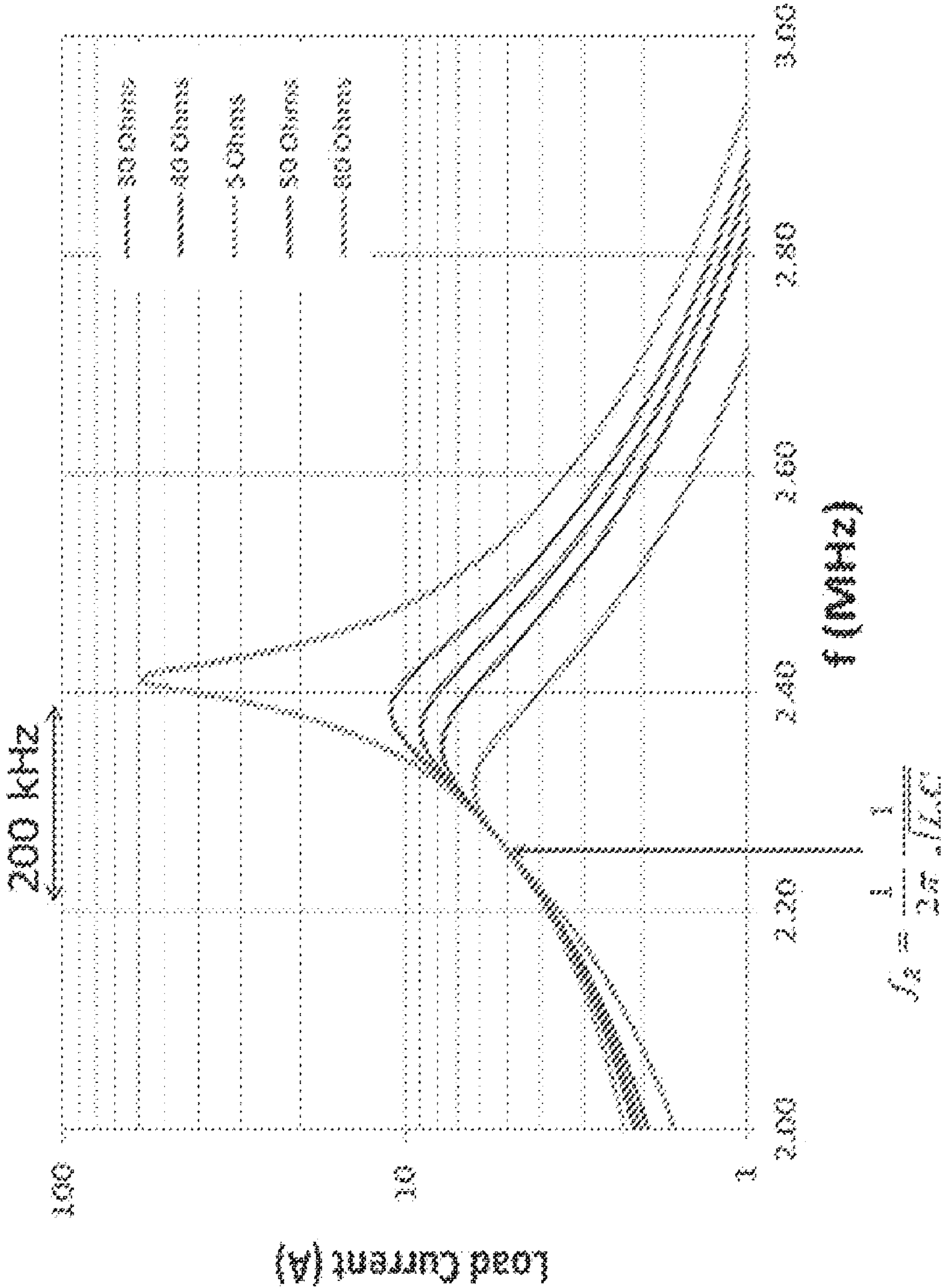


FIG. 33

■ Use of current source

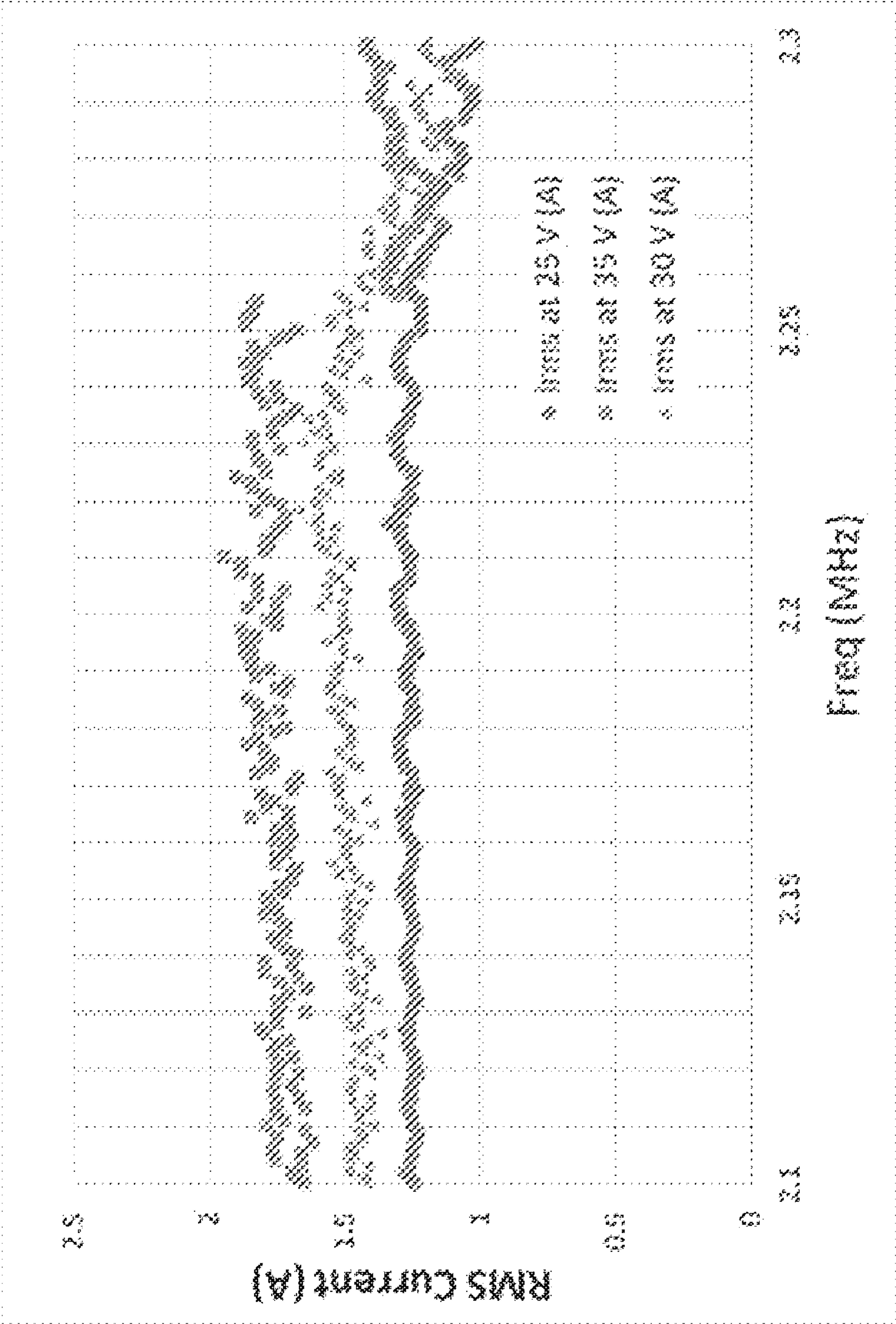


FIG. 34

■ Output power onto the crystal:

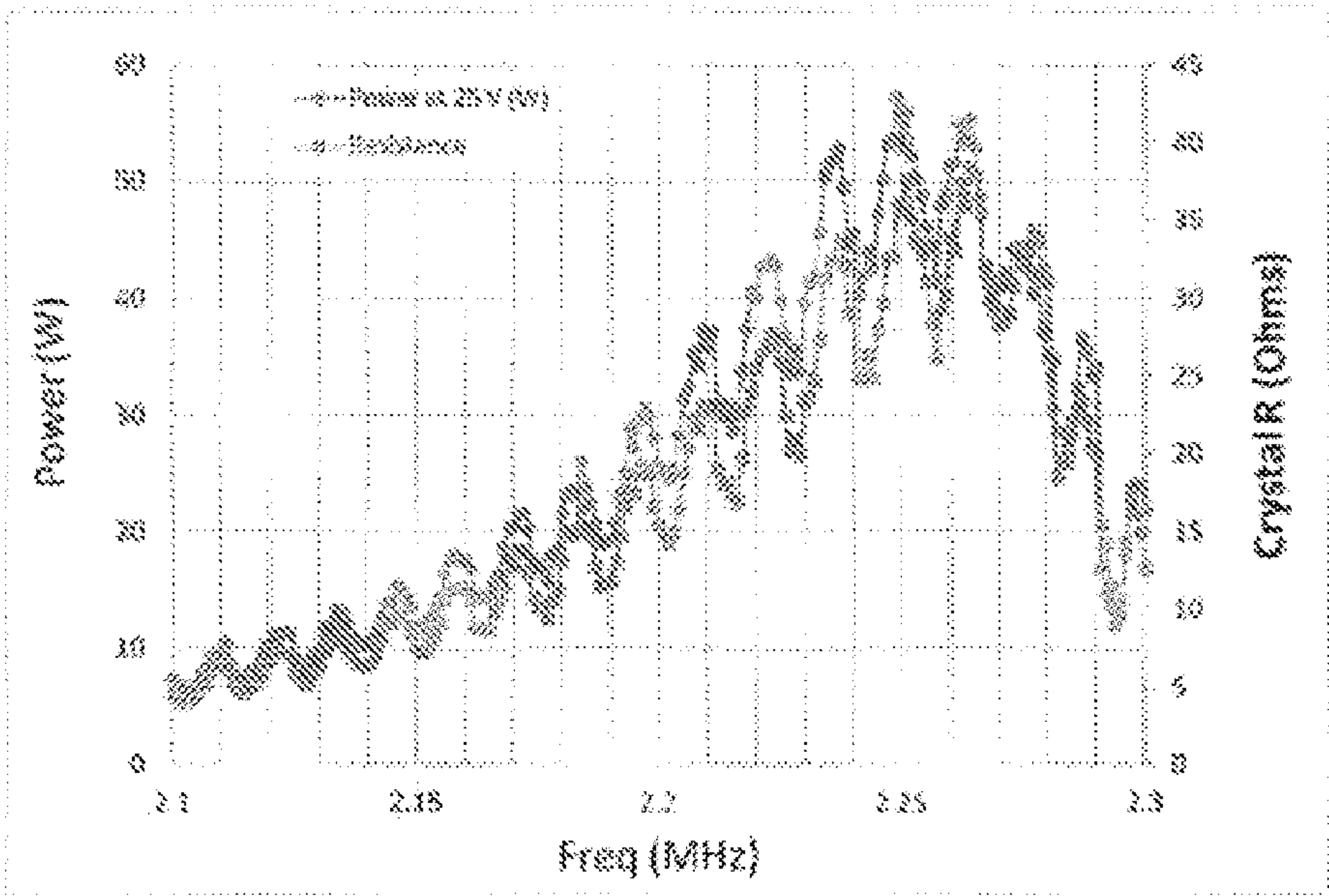


FIG. 35

■ Output power onto the crystal:

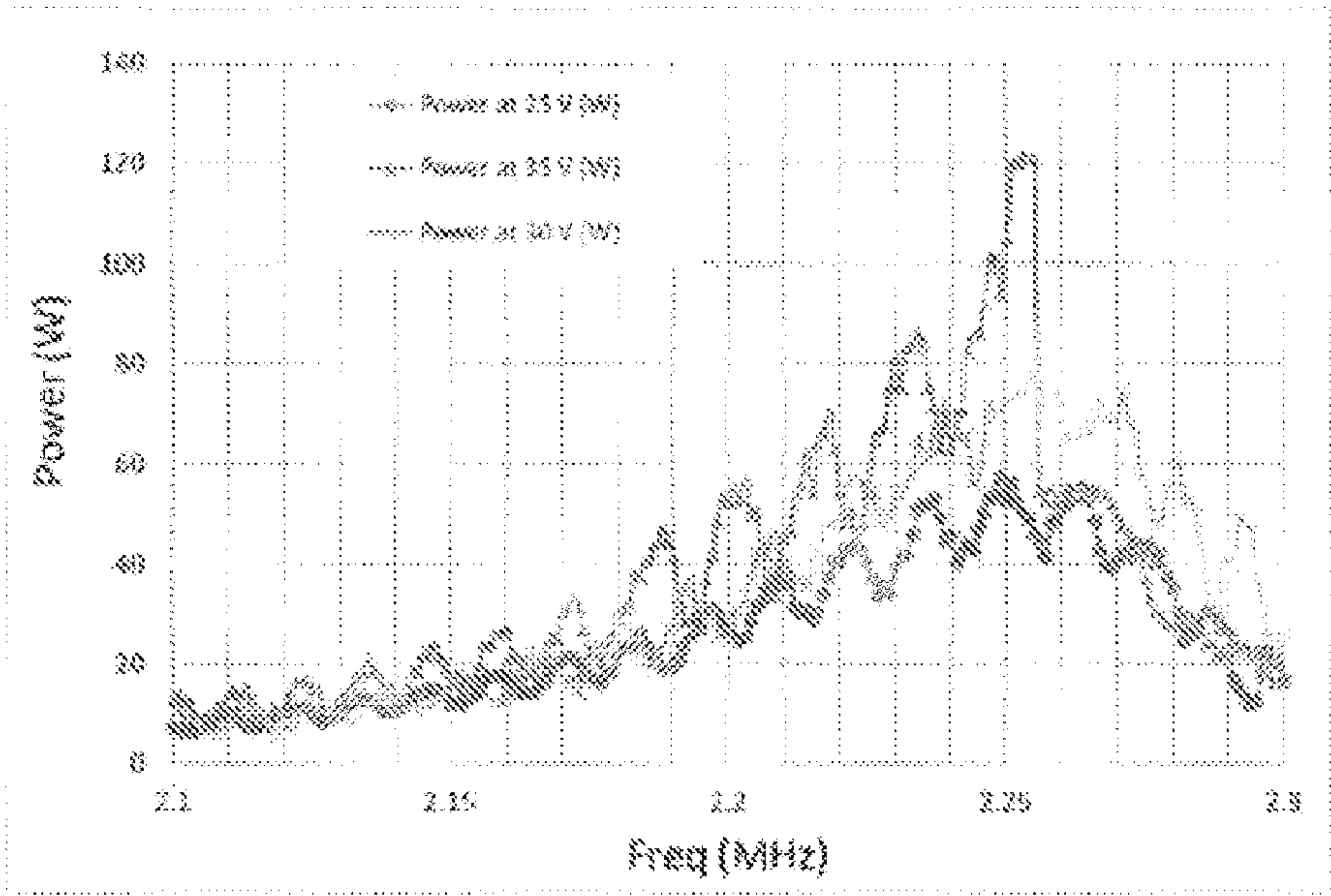


FIG. 36

■ Output current onto the crystal:

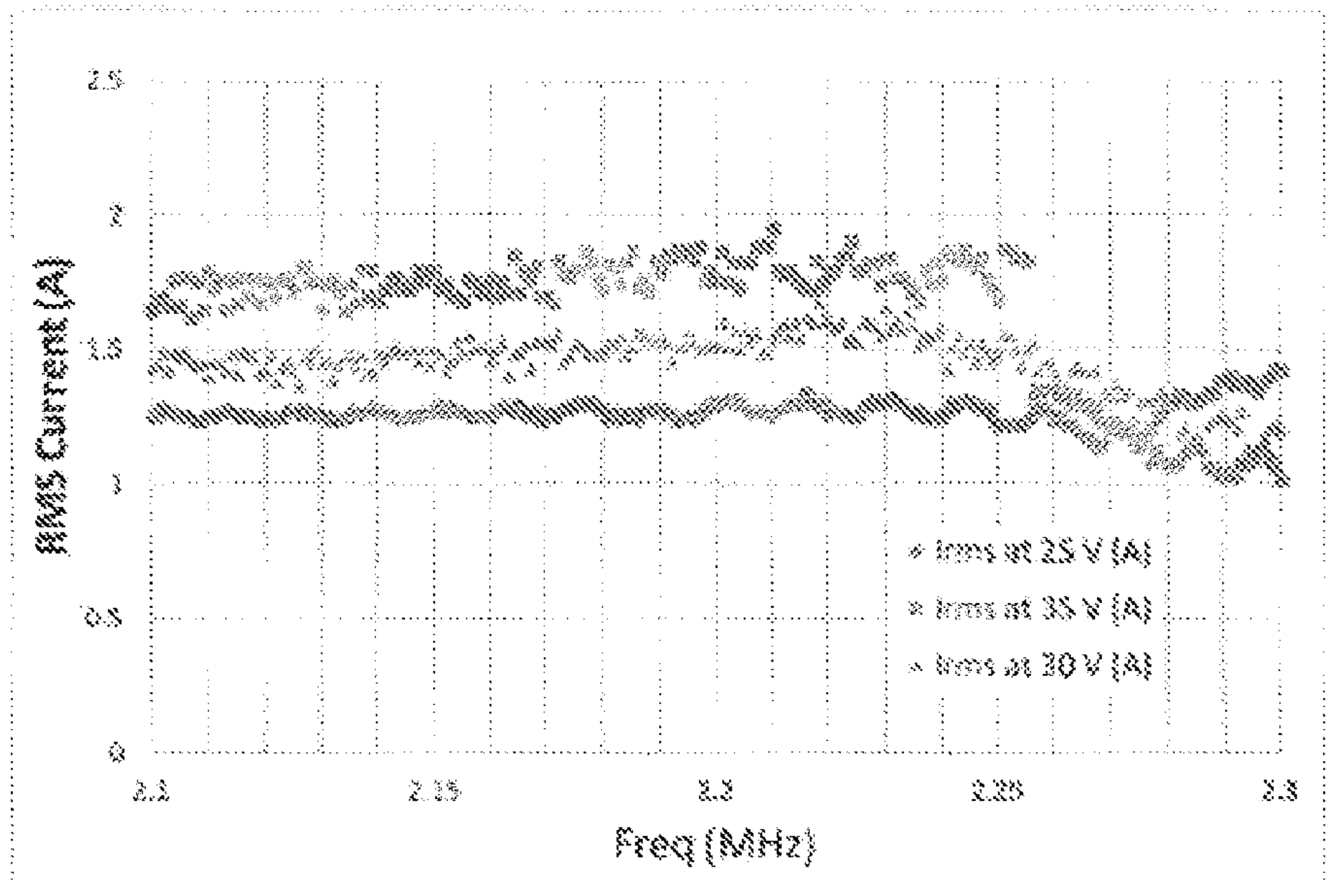


FIG. 37

■ Projected output power onto the crystal:

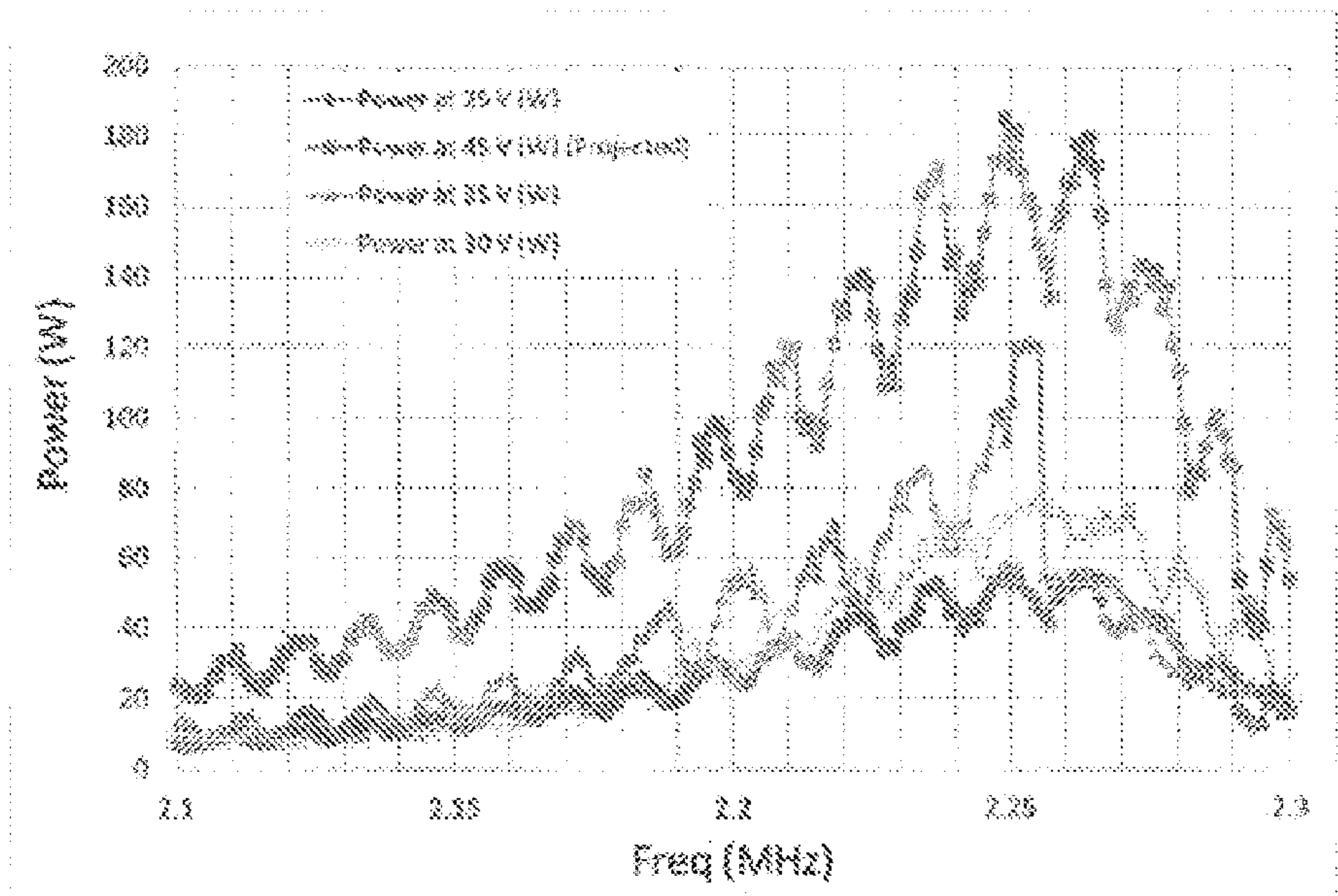


FIG. 38

■ Constant current half-bridge topology:

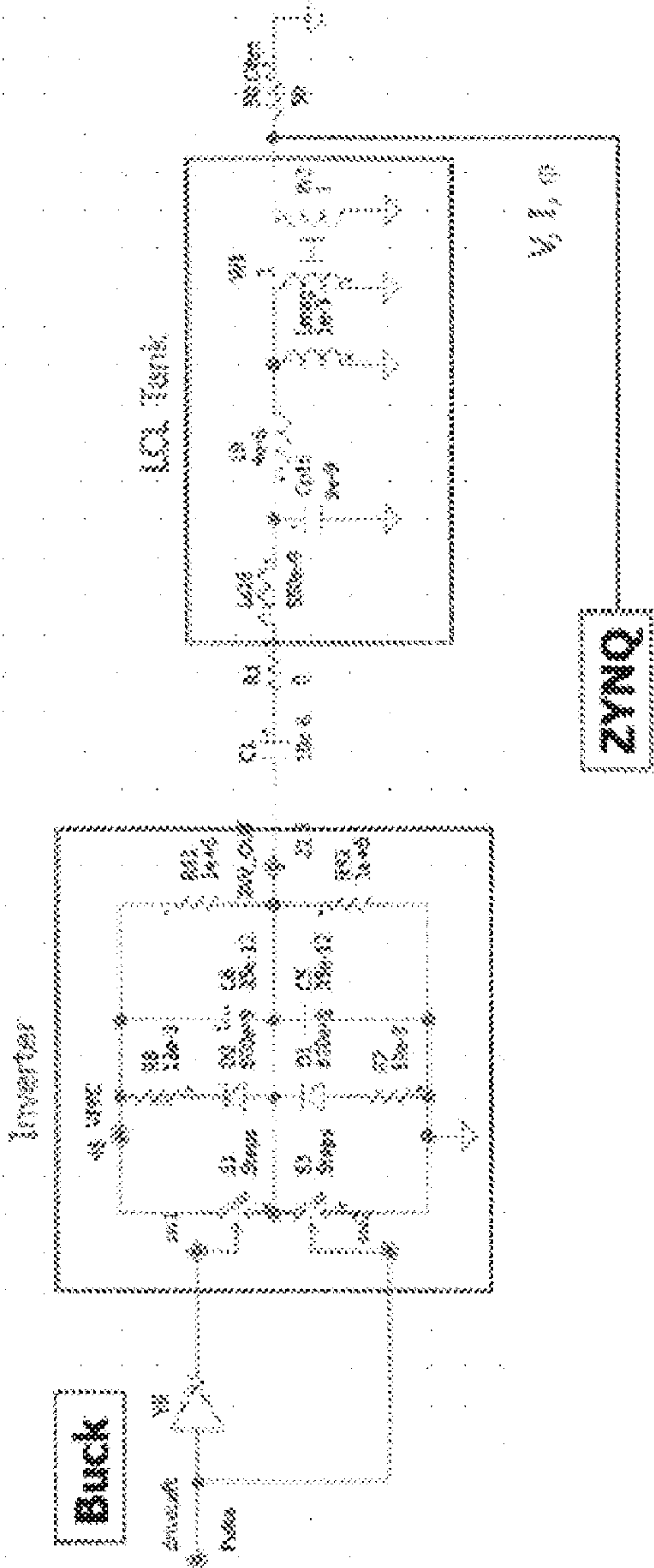


FIG. 39

■ Half-bridge constant current:

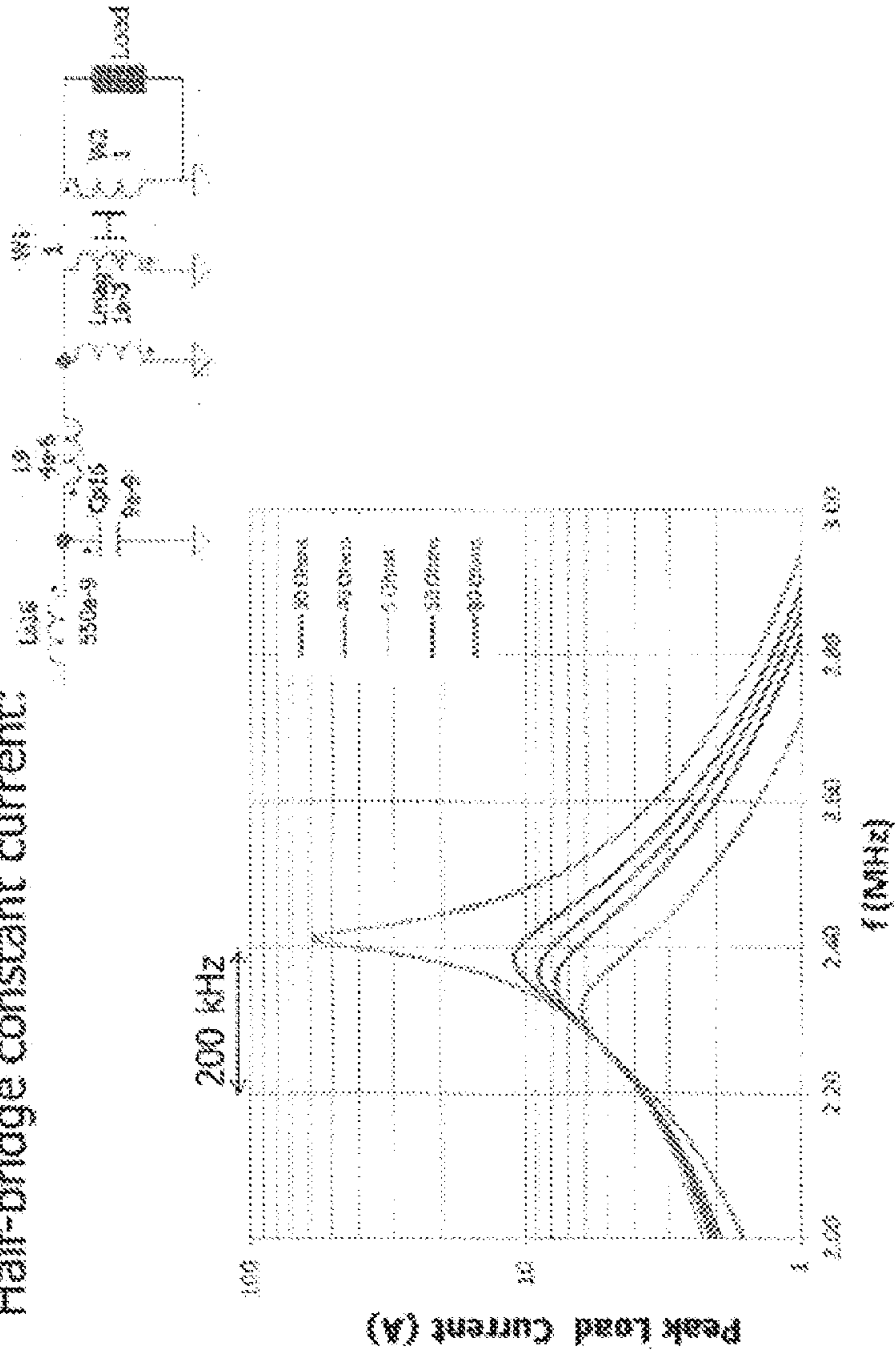


FIG. 40

Half-bridge constant current:

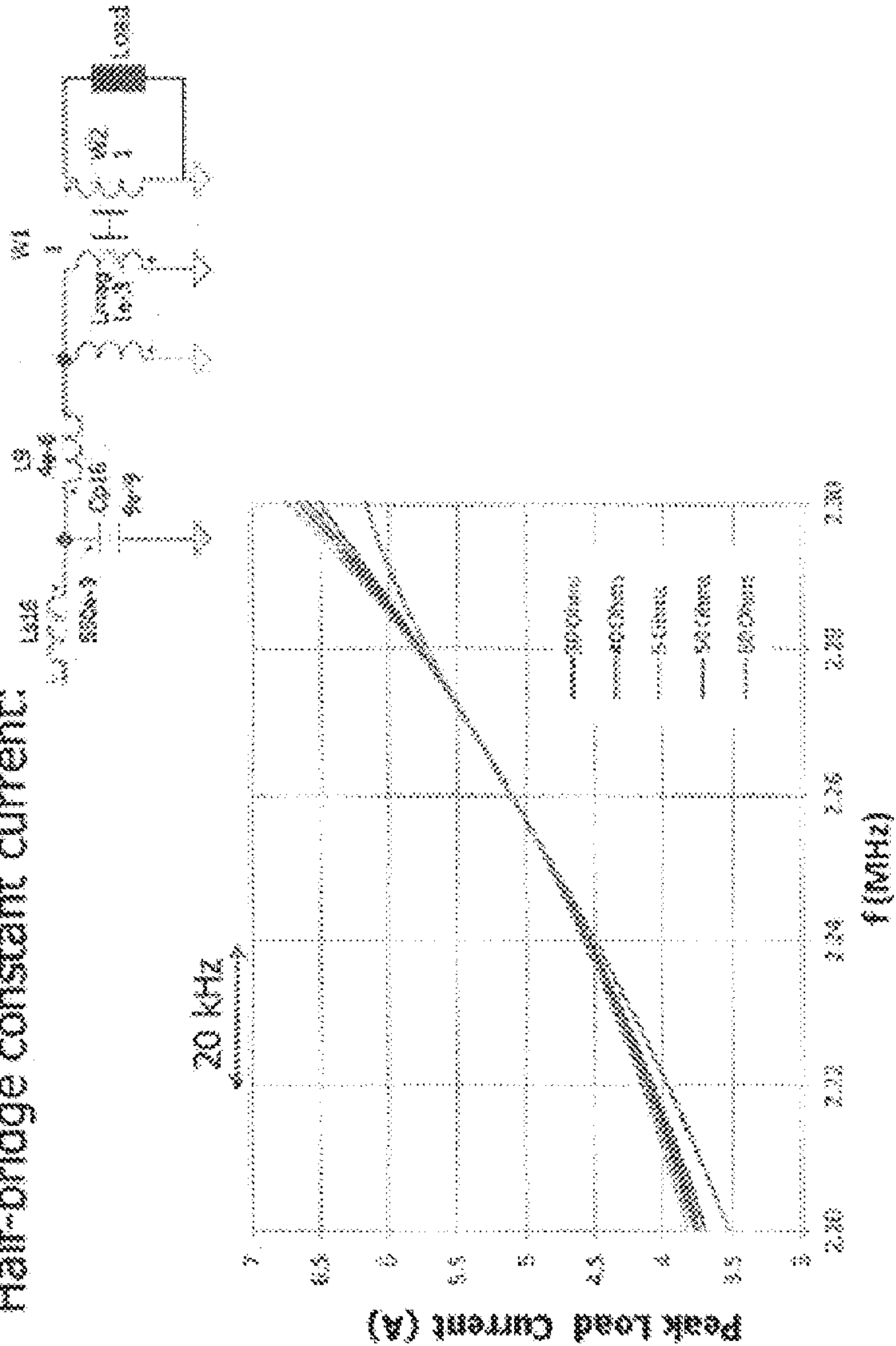


FIG. 41

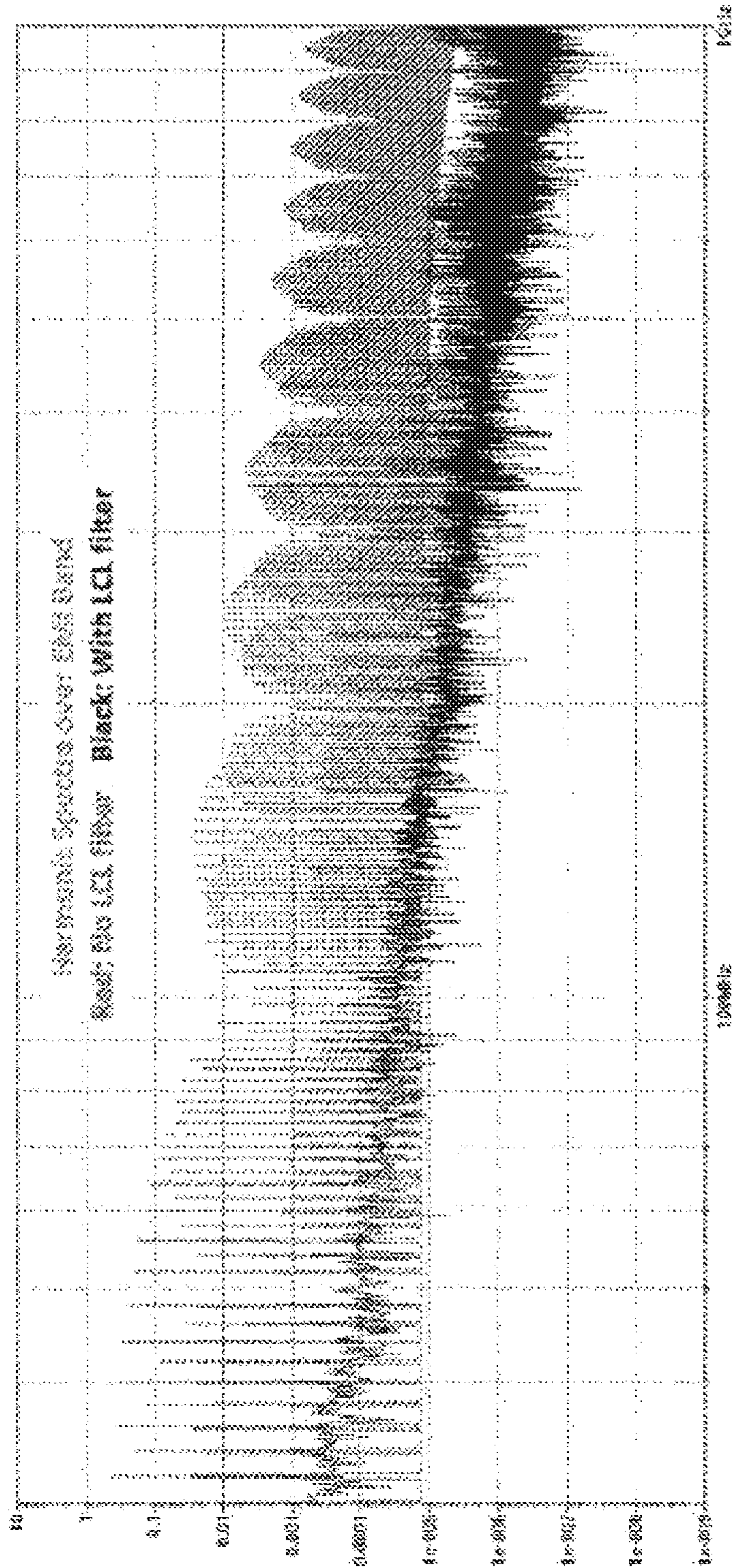


FIG. 42

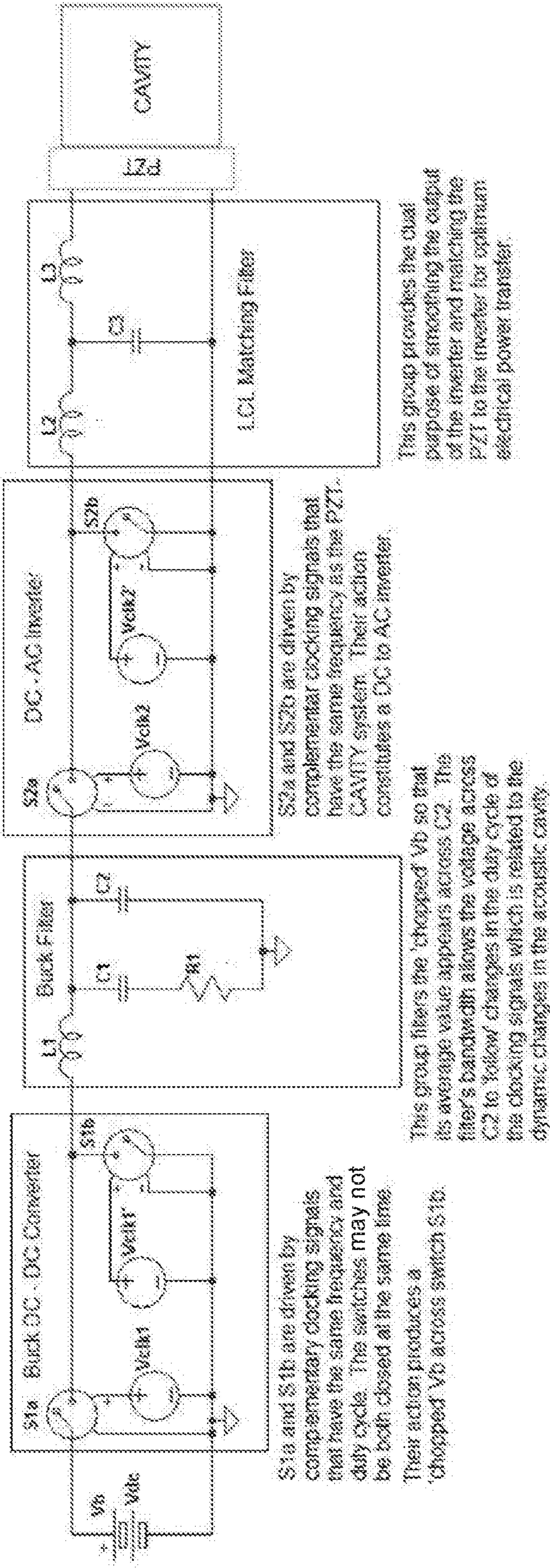


FIG. 43

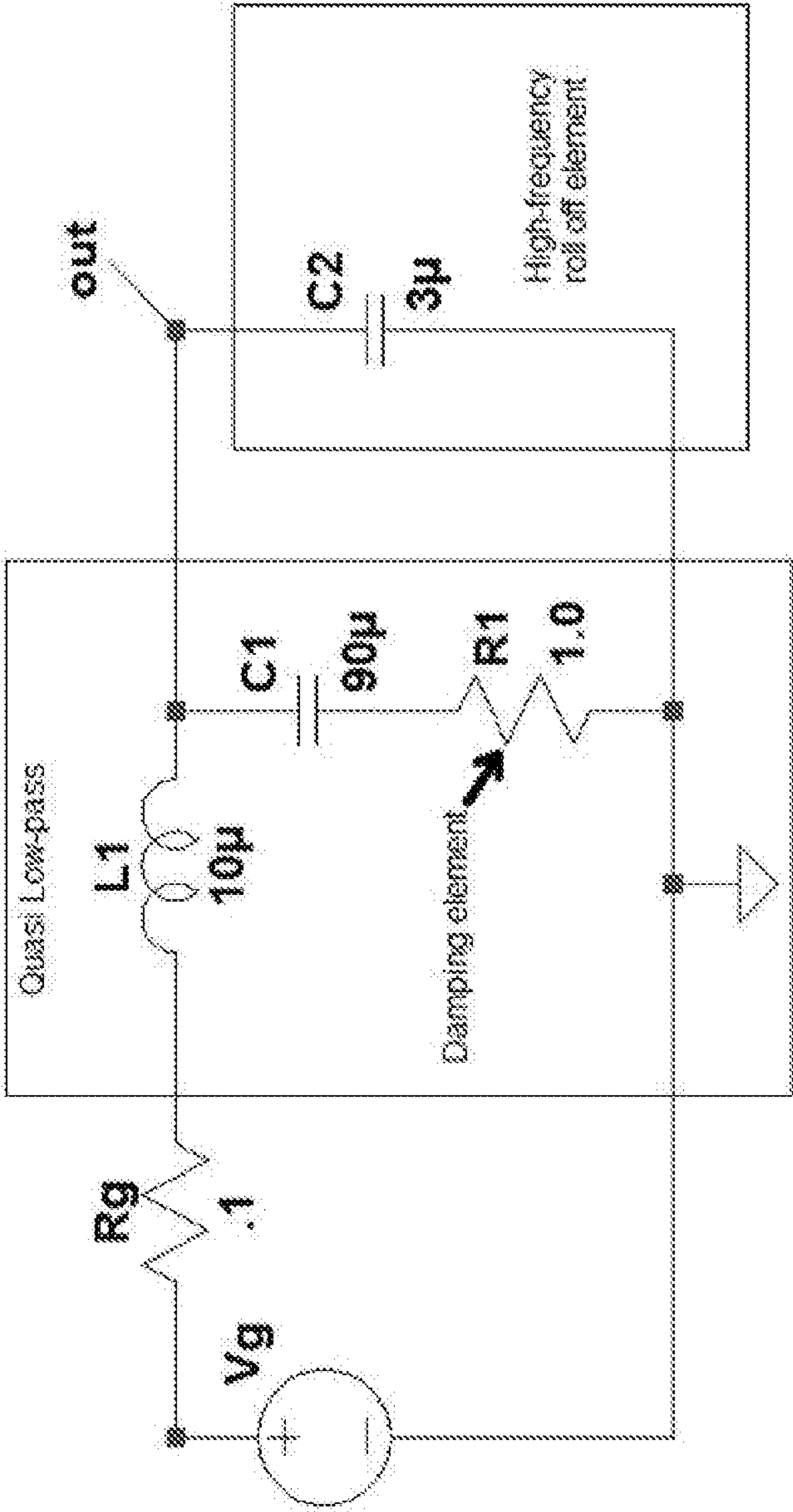


FIG. 44

Find Minimum/Maximum Reactance Algorithm

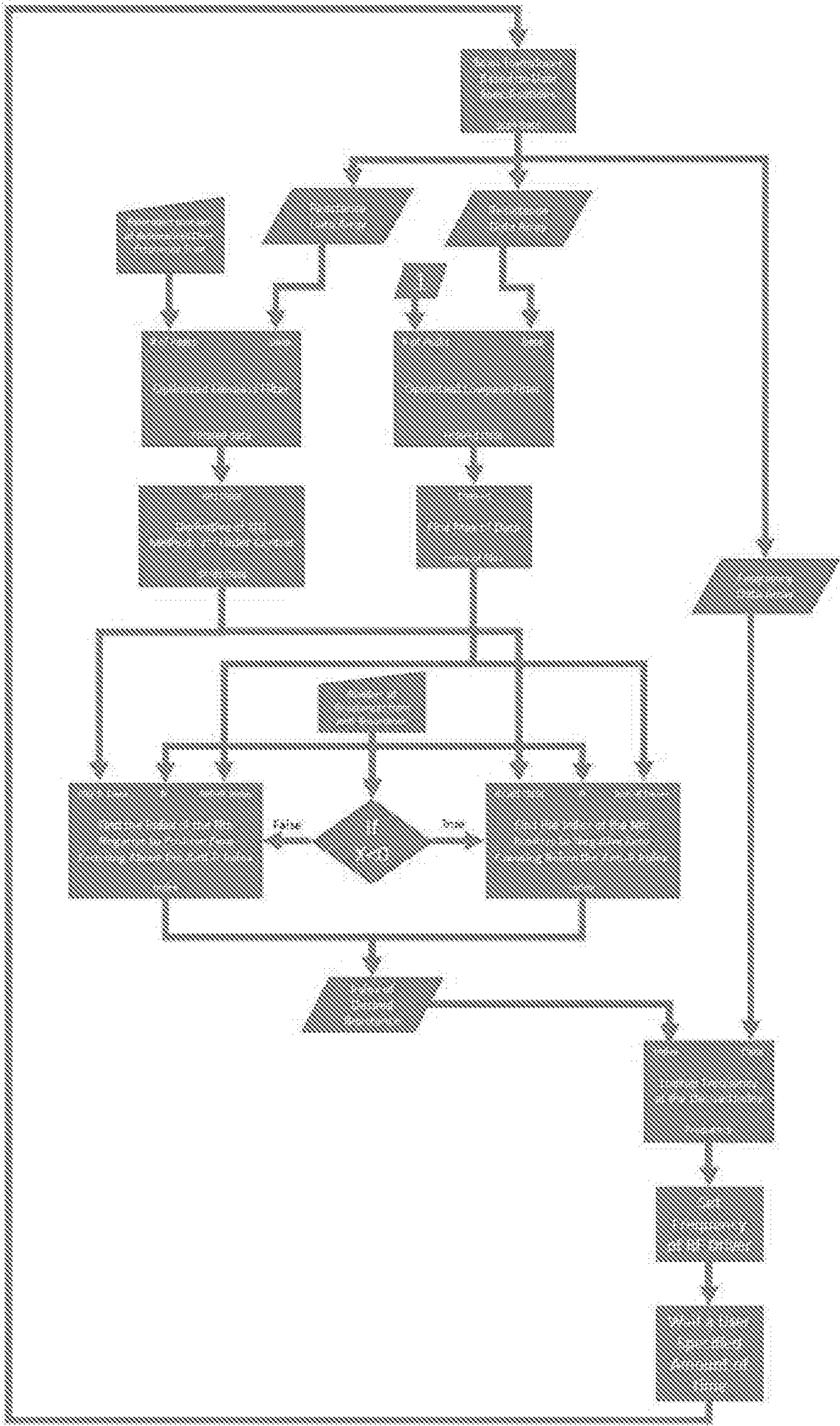


FIG. 45

Optimized Lowpass Filter

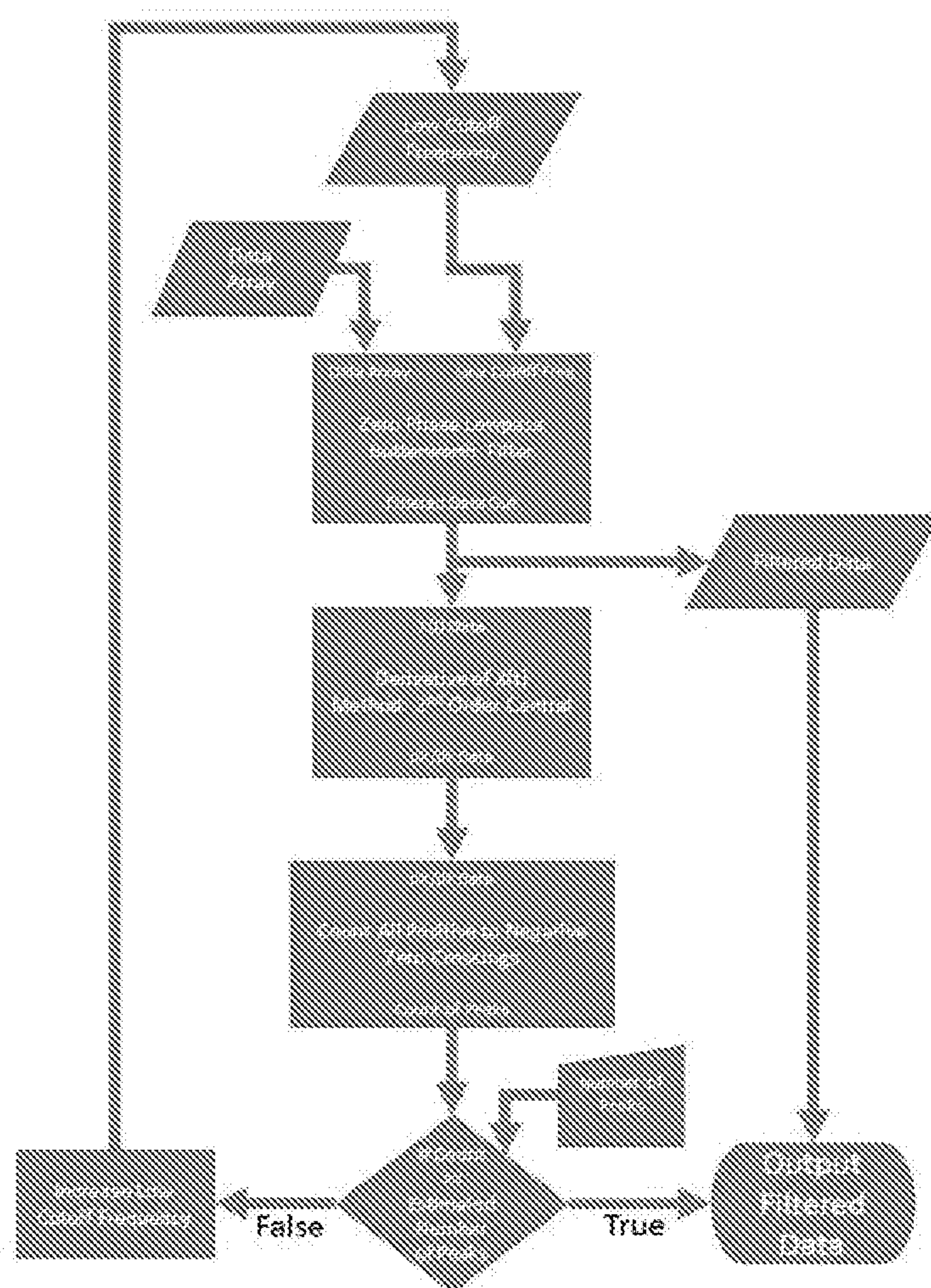


FIG. 46

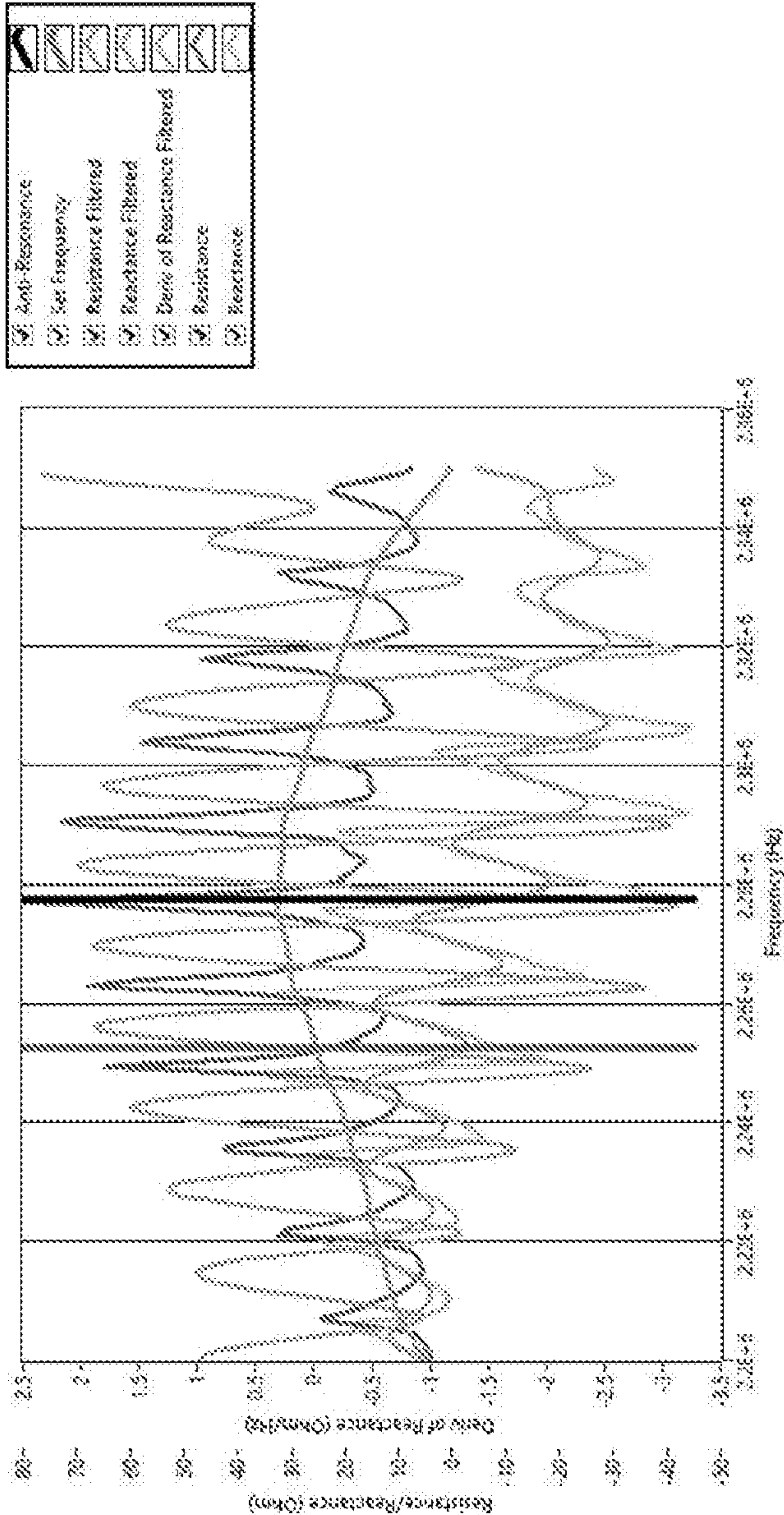


FIG. 47

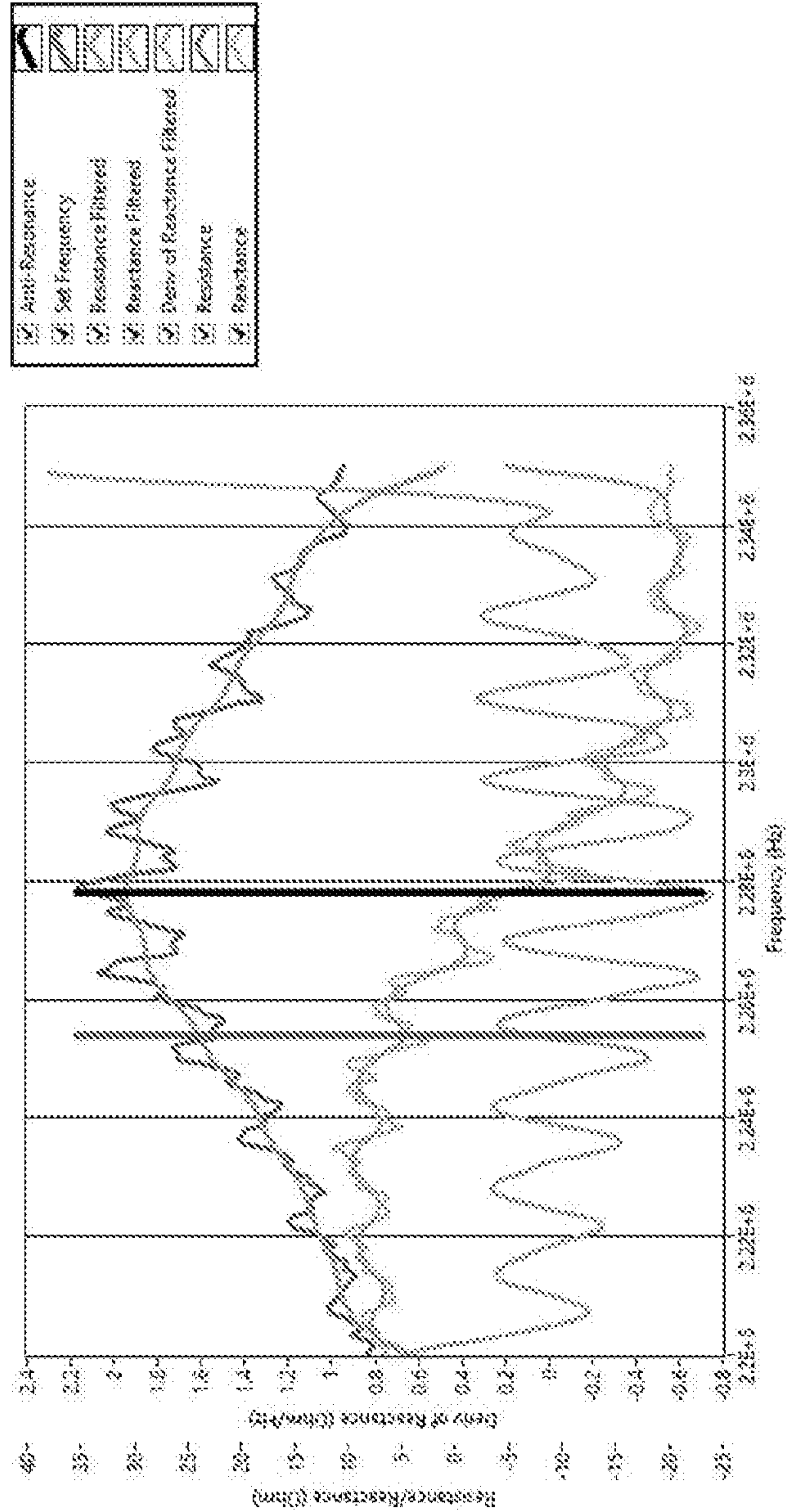


FIG. 48

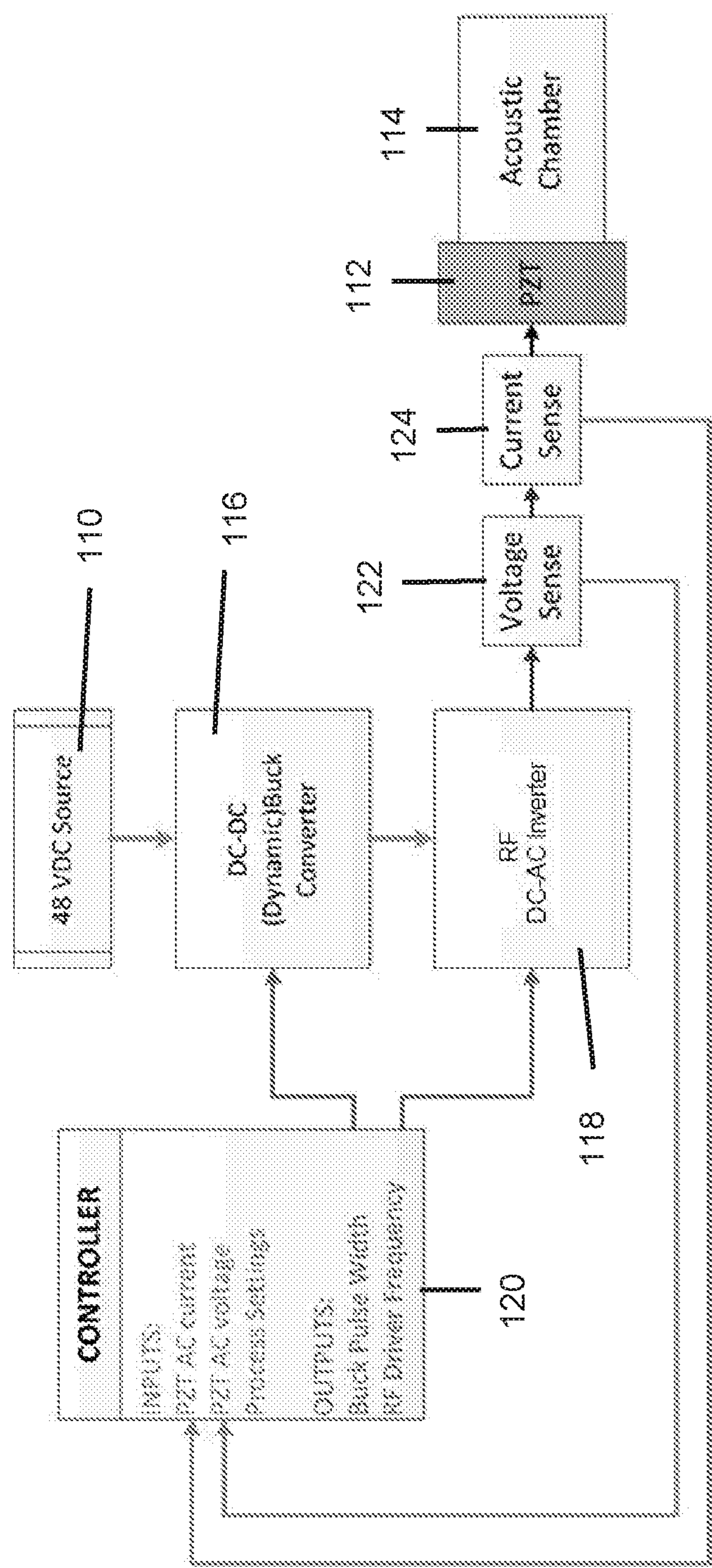


FIG. 49

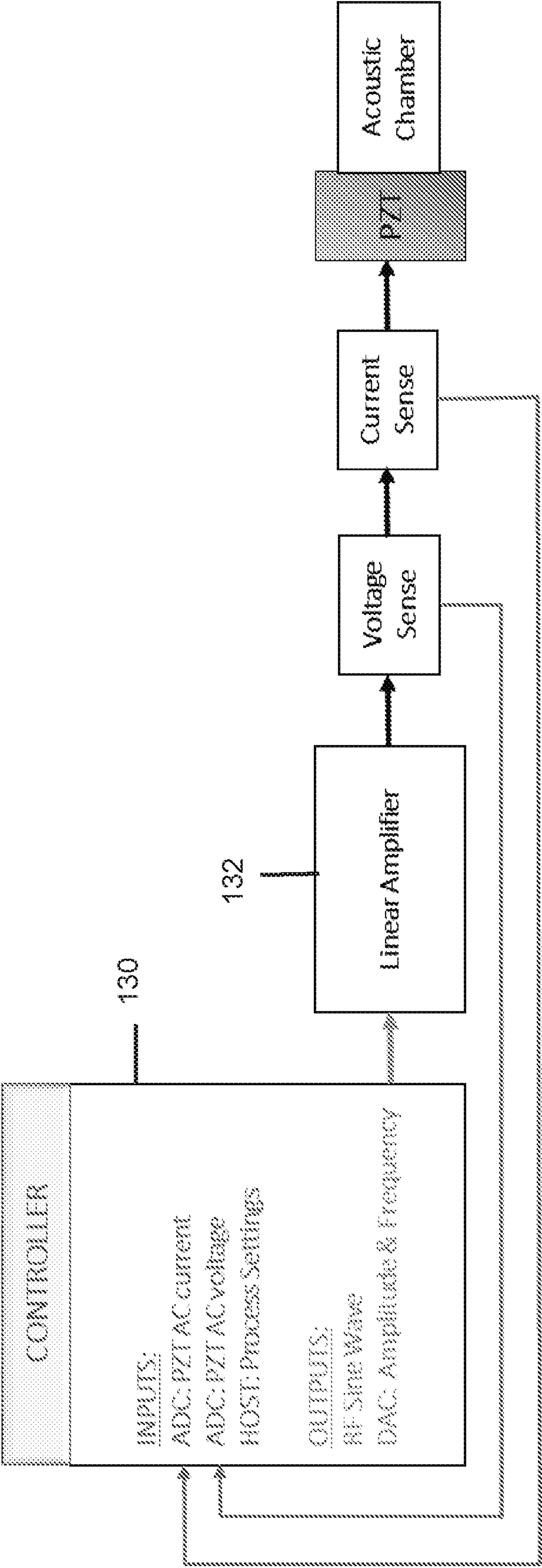


FIG. 50

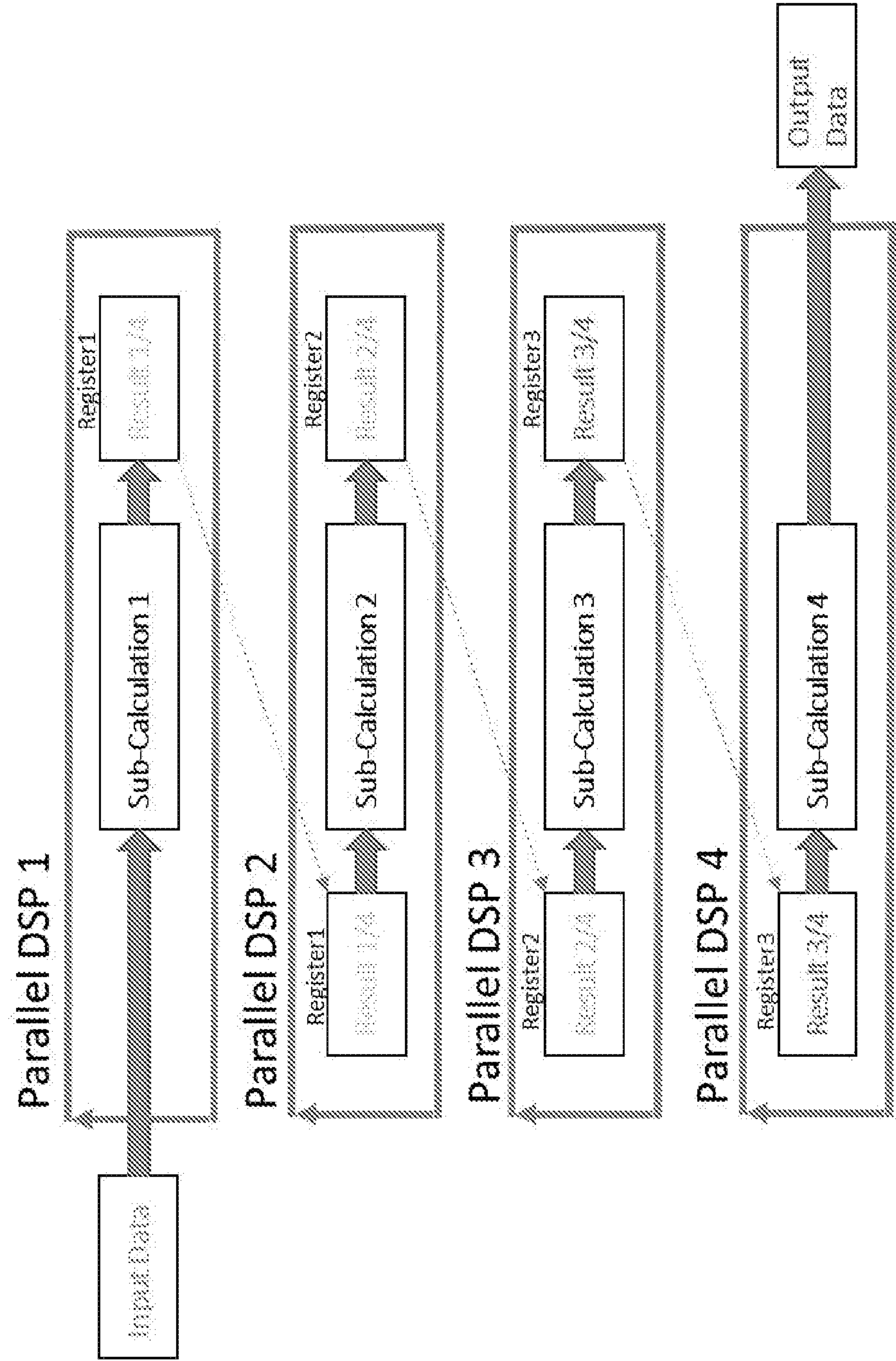


FIG. 51

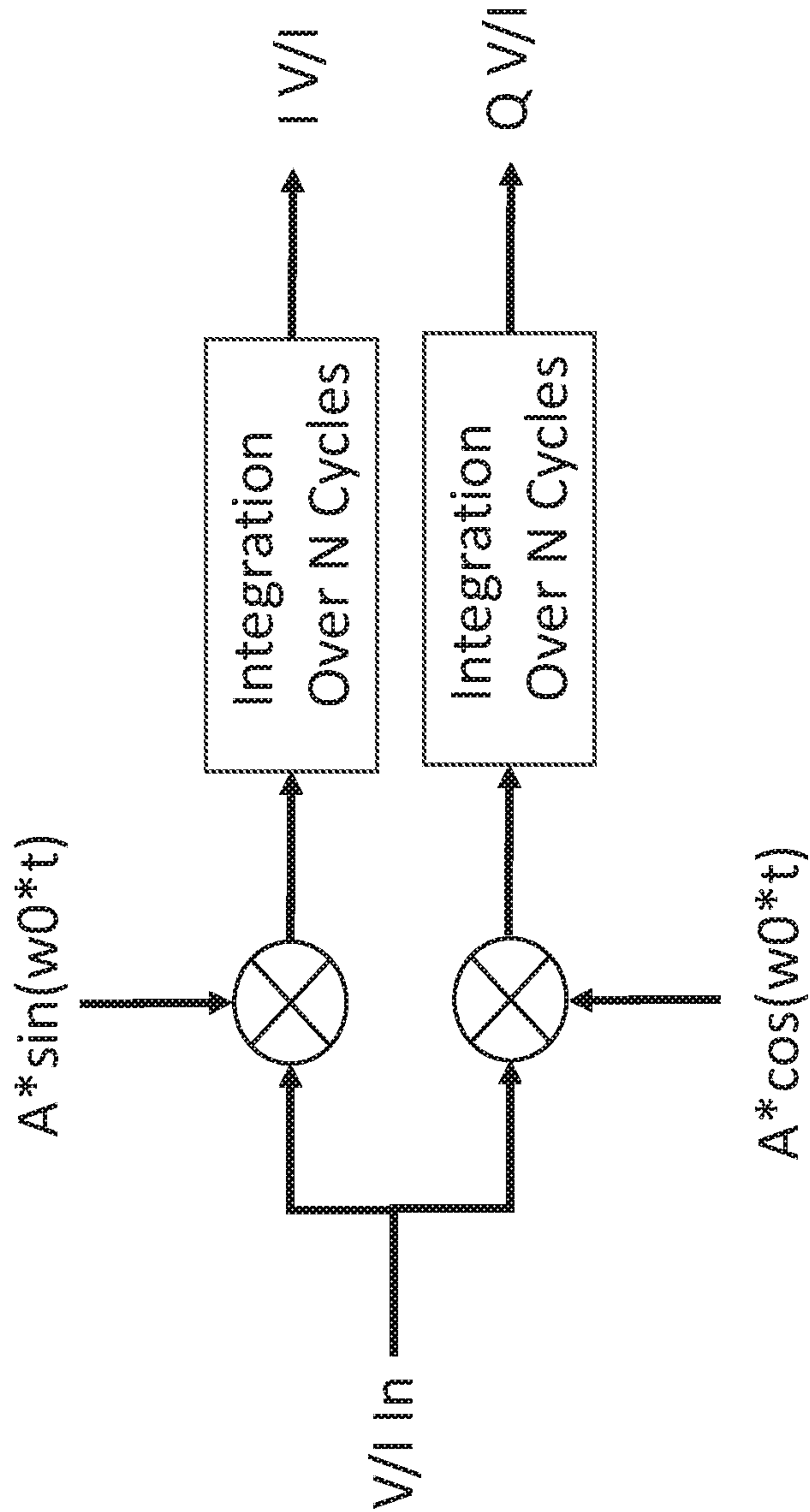


FIG. 52

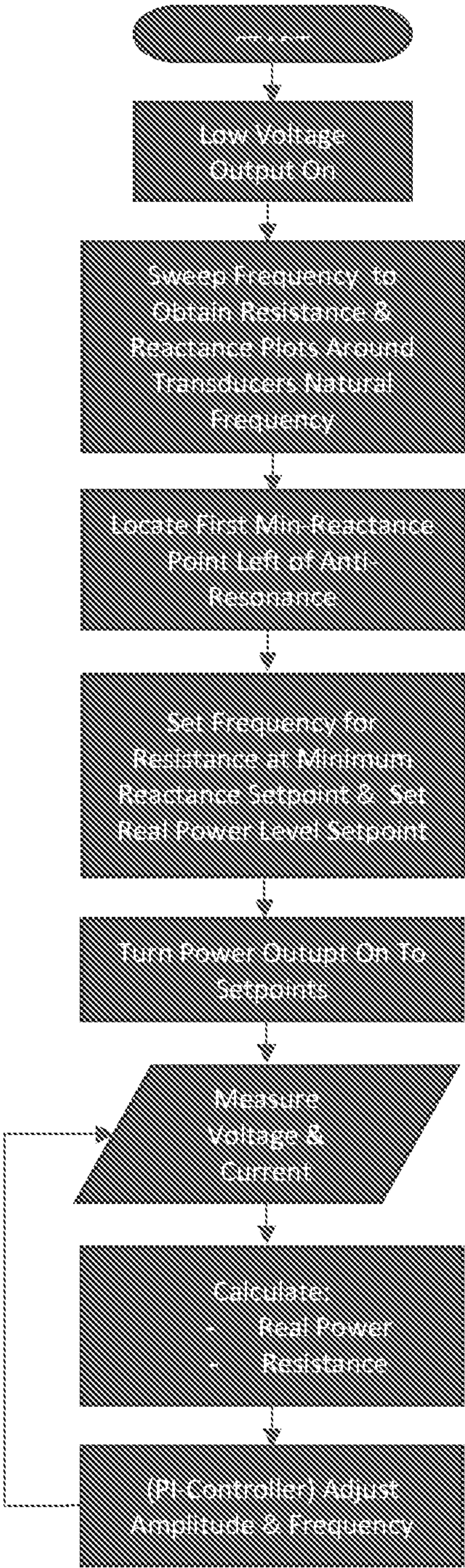


FIG. 53

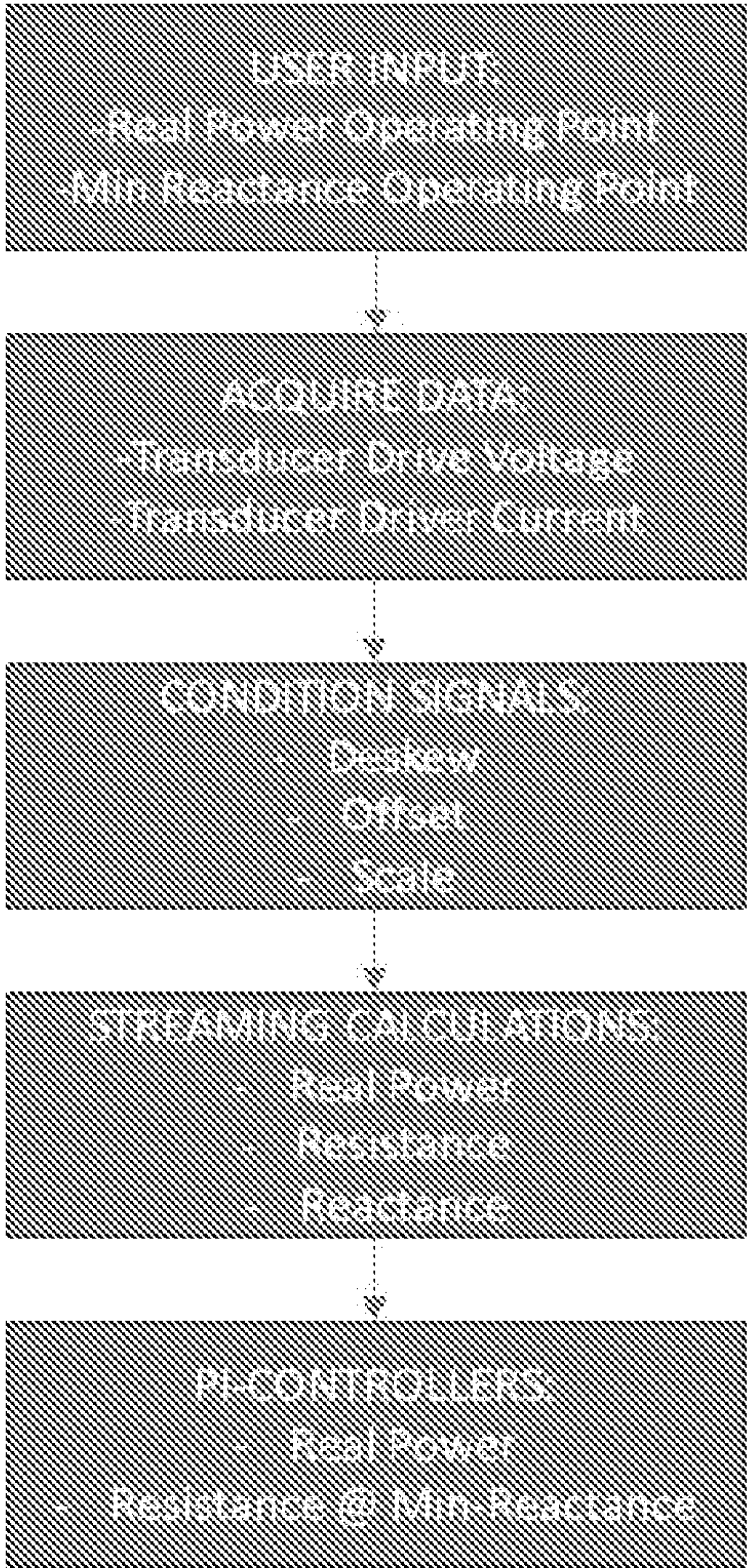


FIG. 54

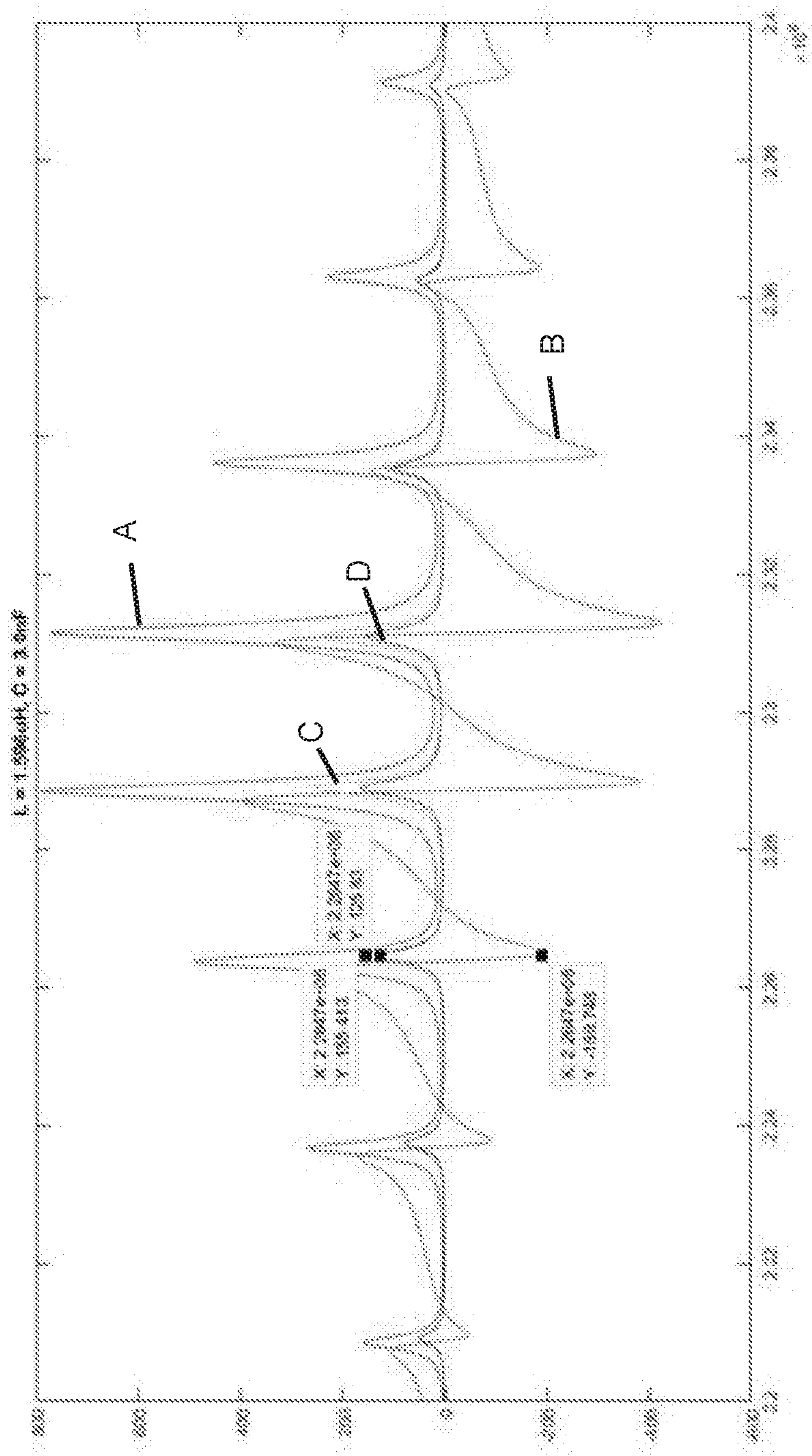


FIG. 55

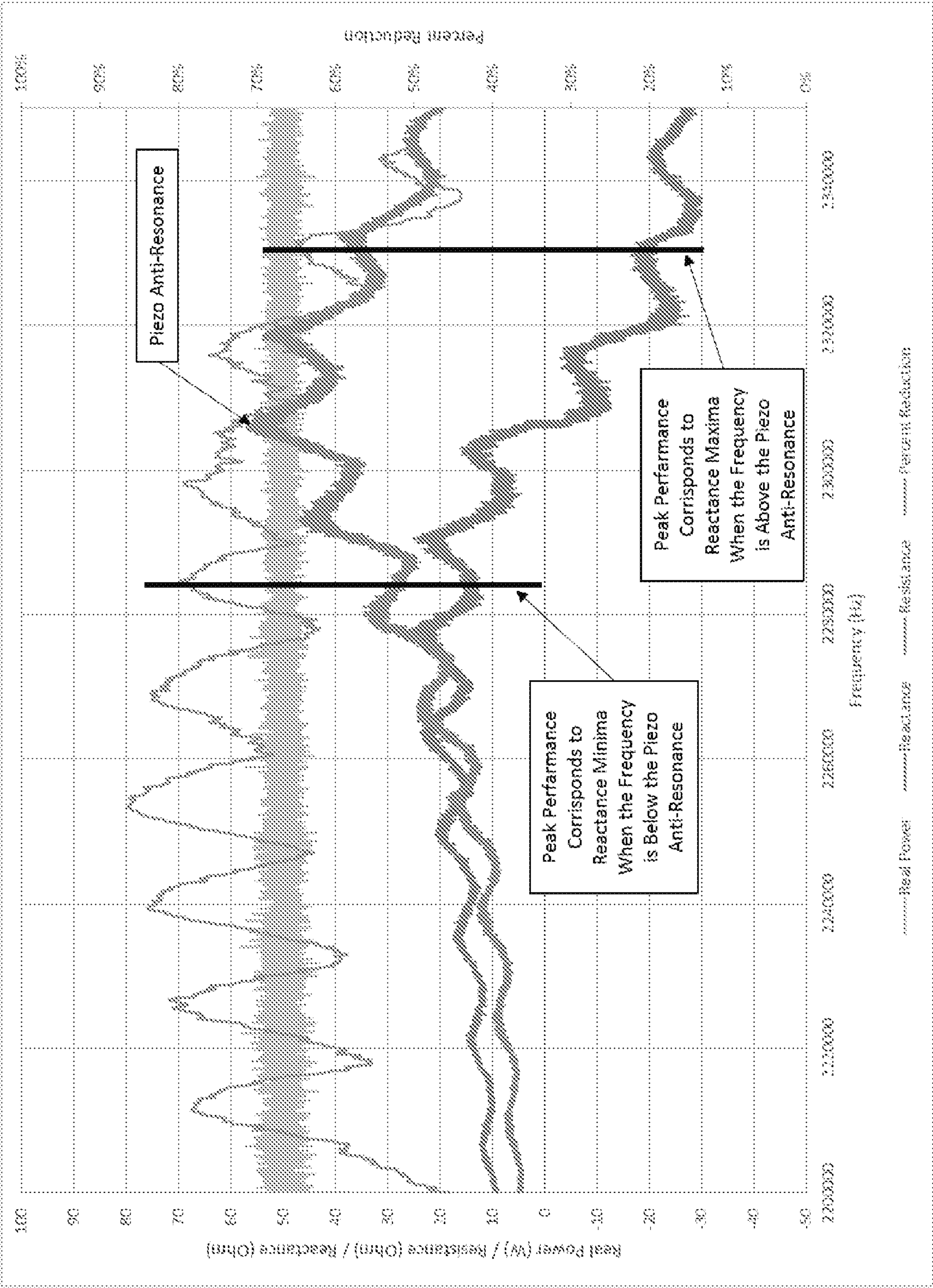
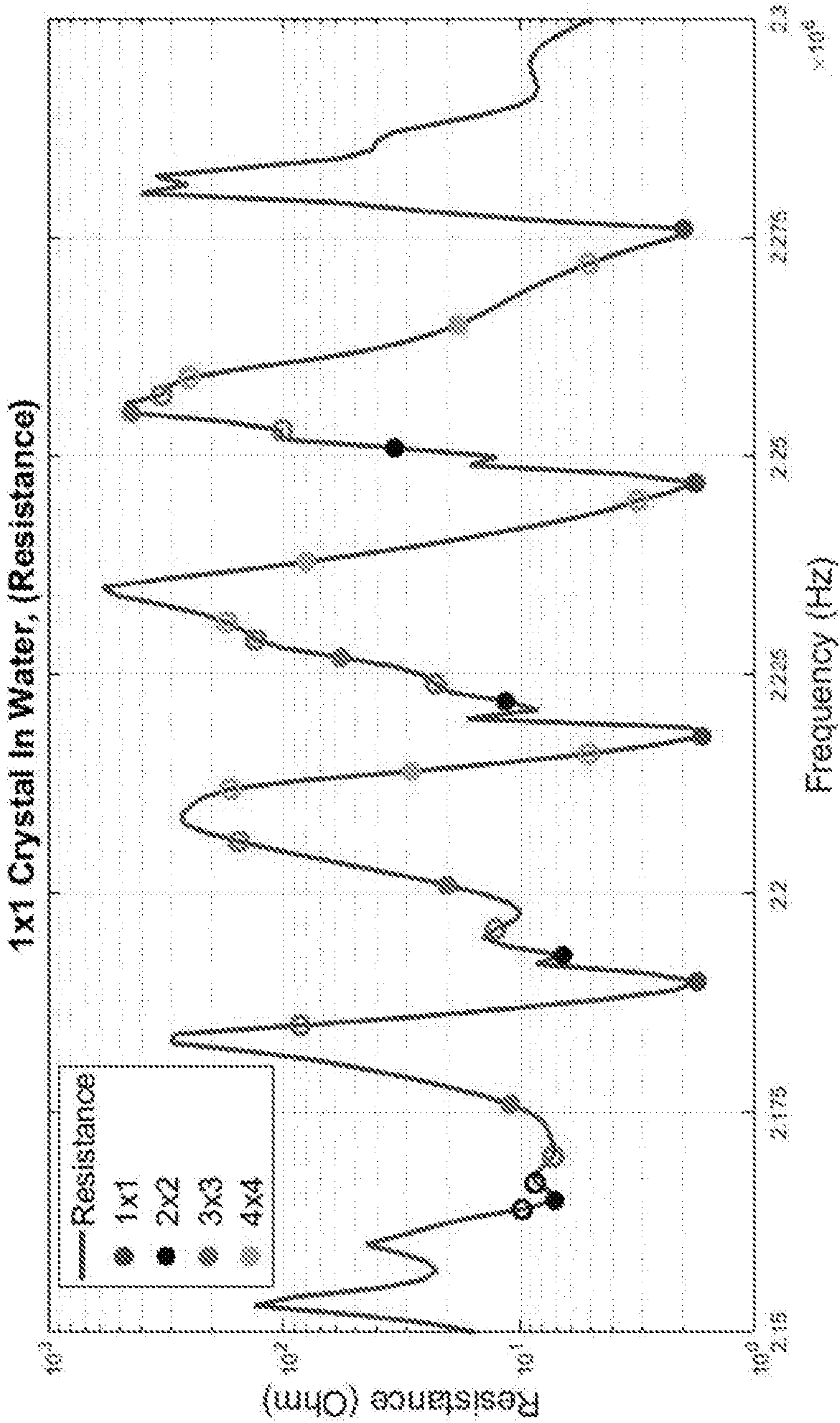
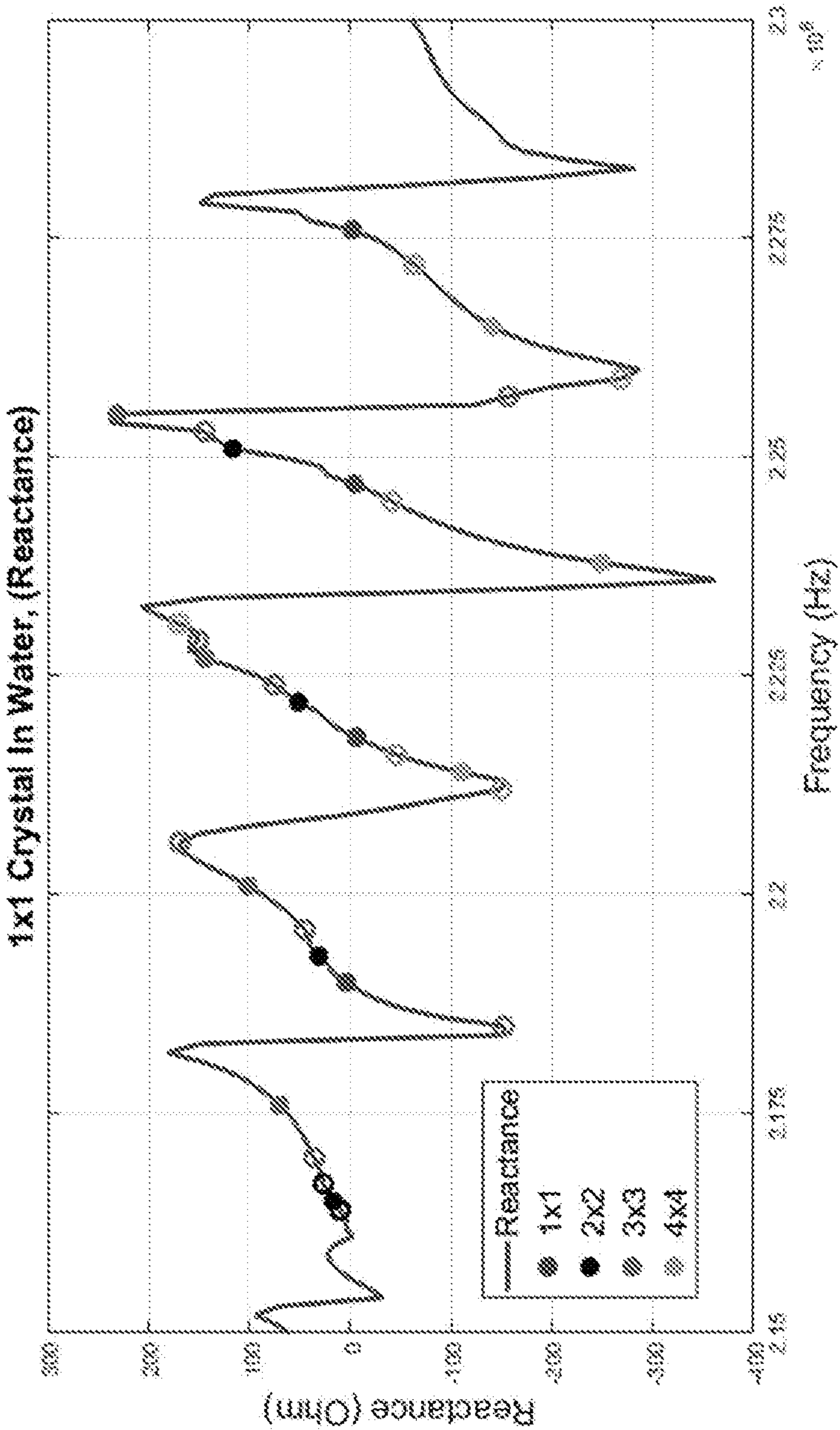


FIG. 56



- Solid circles are pure modes
- Hollow circles are where the mode first occurs and disappears

FIG. 57



- Solid circles are pure modes
- Hollow circles are where the first mode first occurs and disappears

FIG.58

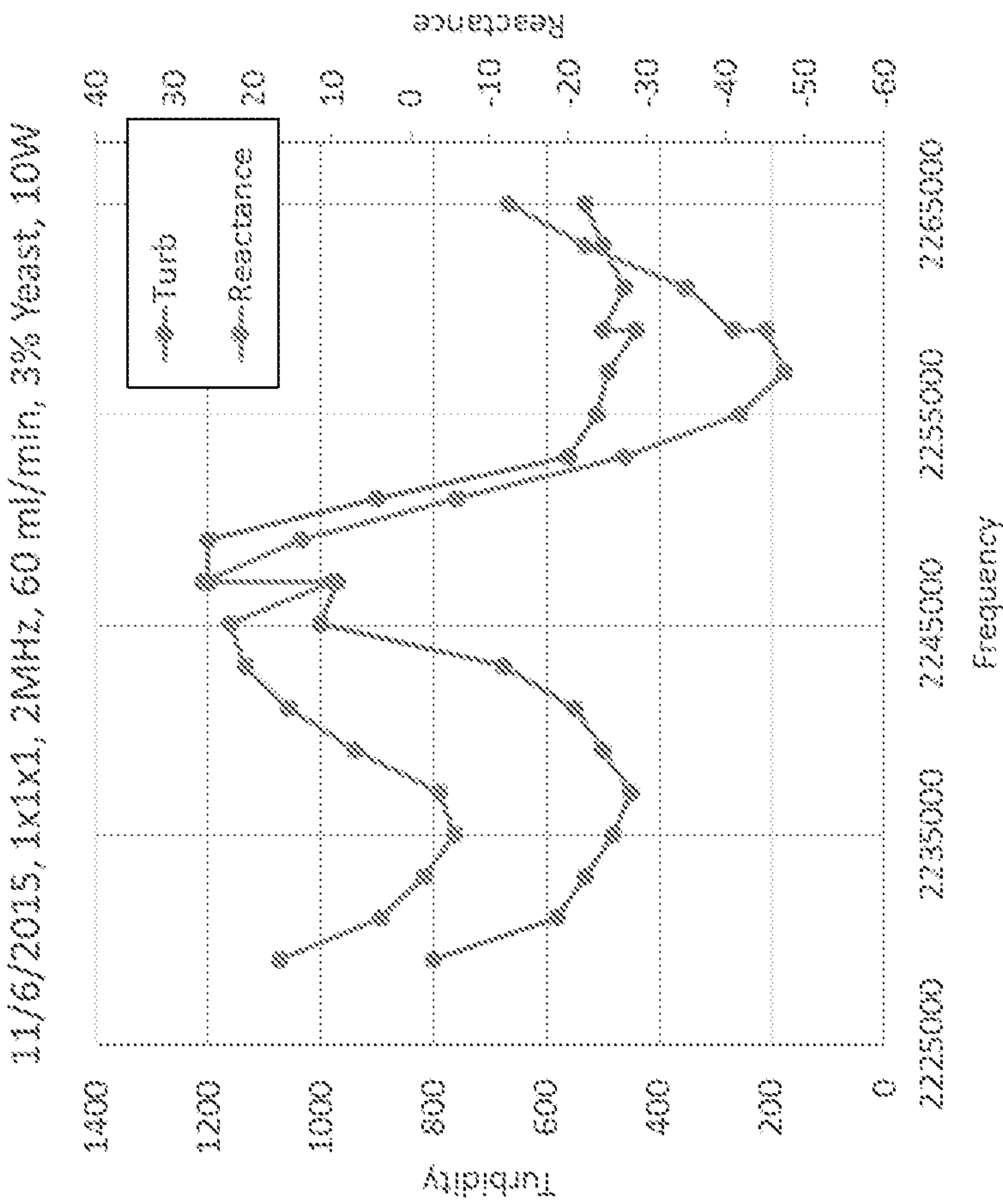


FIG. 59

- 1x1x1
- 3% Yeast
- 2 MHz
- 60 ml/min, 10W
- Each frequency ran for 20 minutes to reach a steady state
- Average values plotted

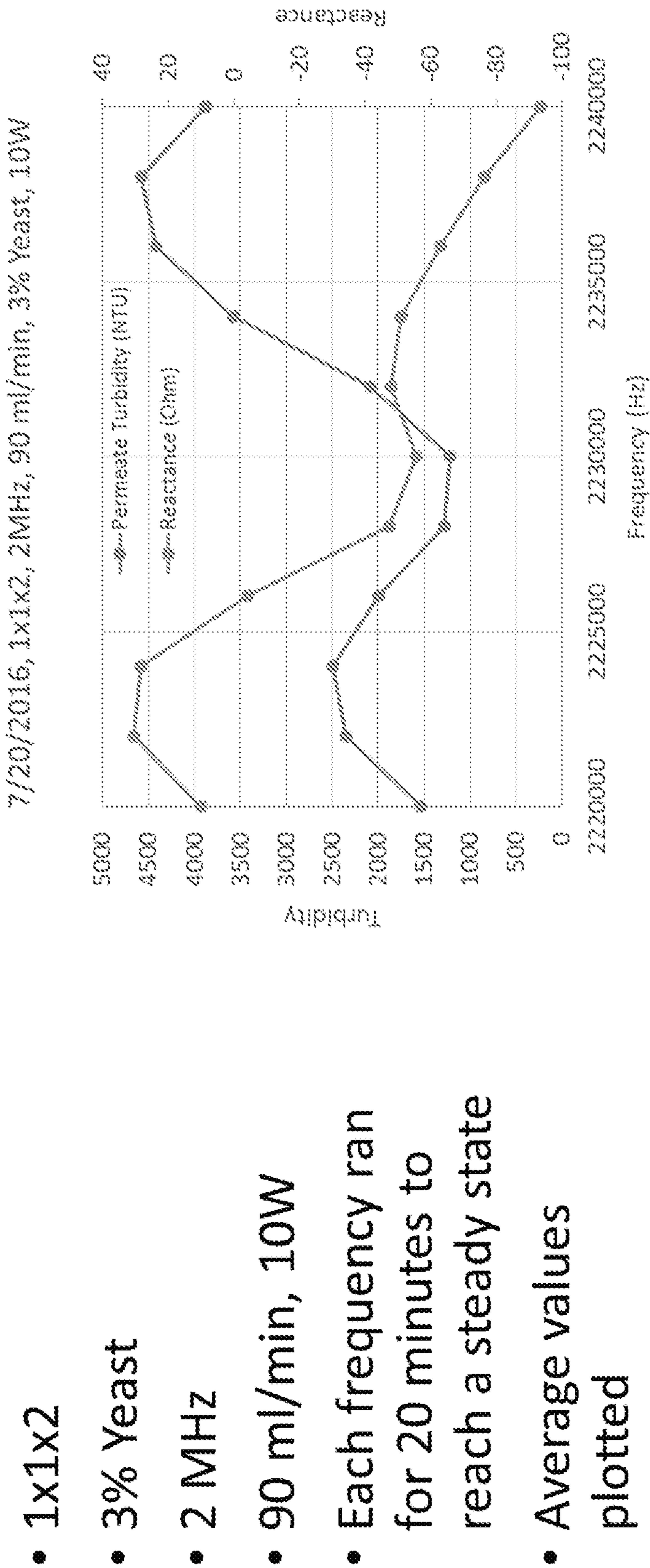


FIG. 60

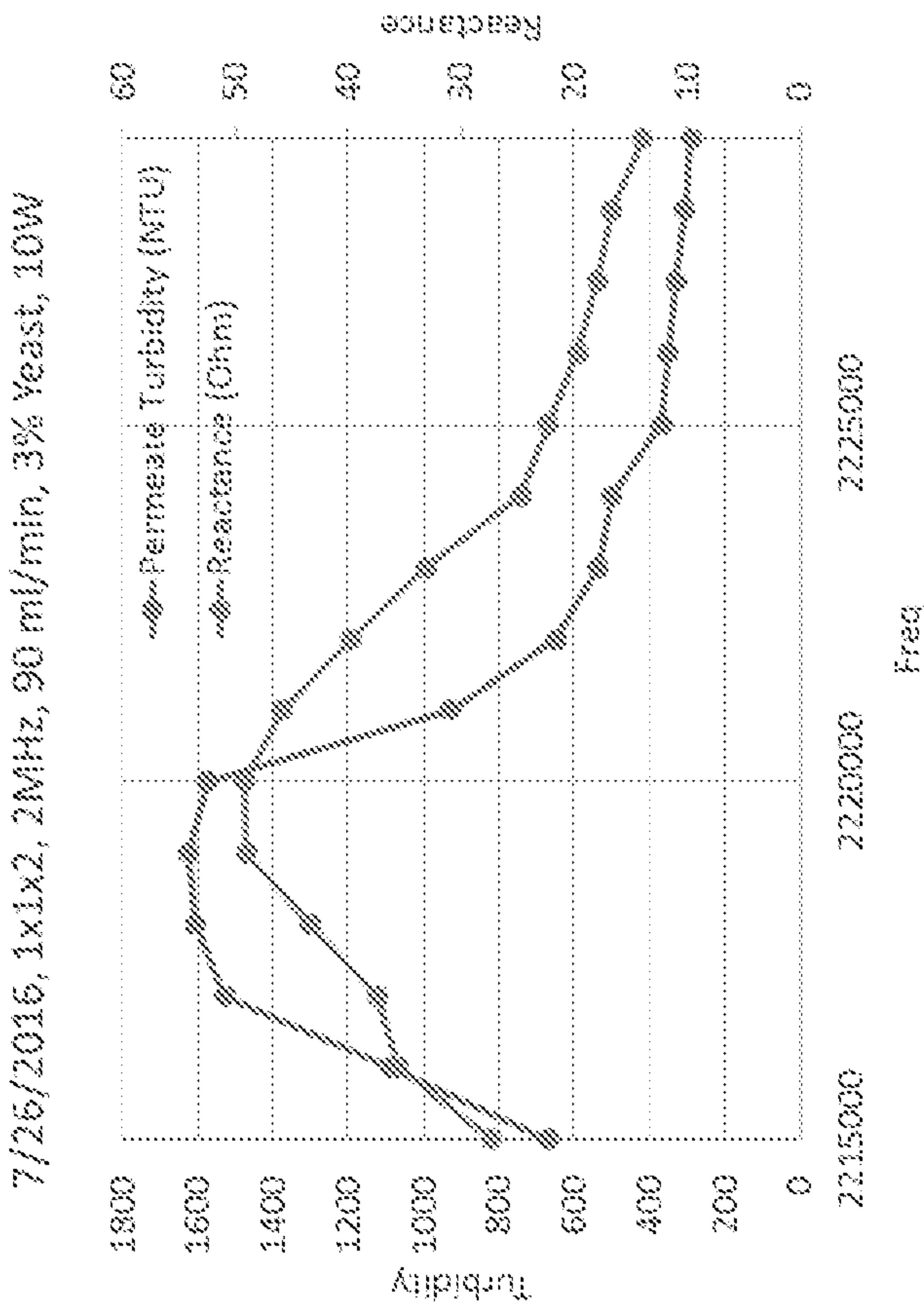


FIG. 61

- 1x1x2
- 3% Yeast
- 2 MHz
- 90 ml/min, 10W
- Each frequency ran for 20 minutes to reach a steady state
- Average values plotted

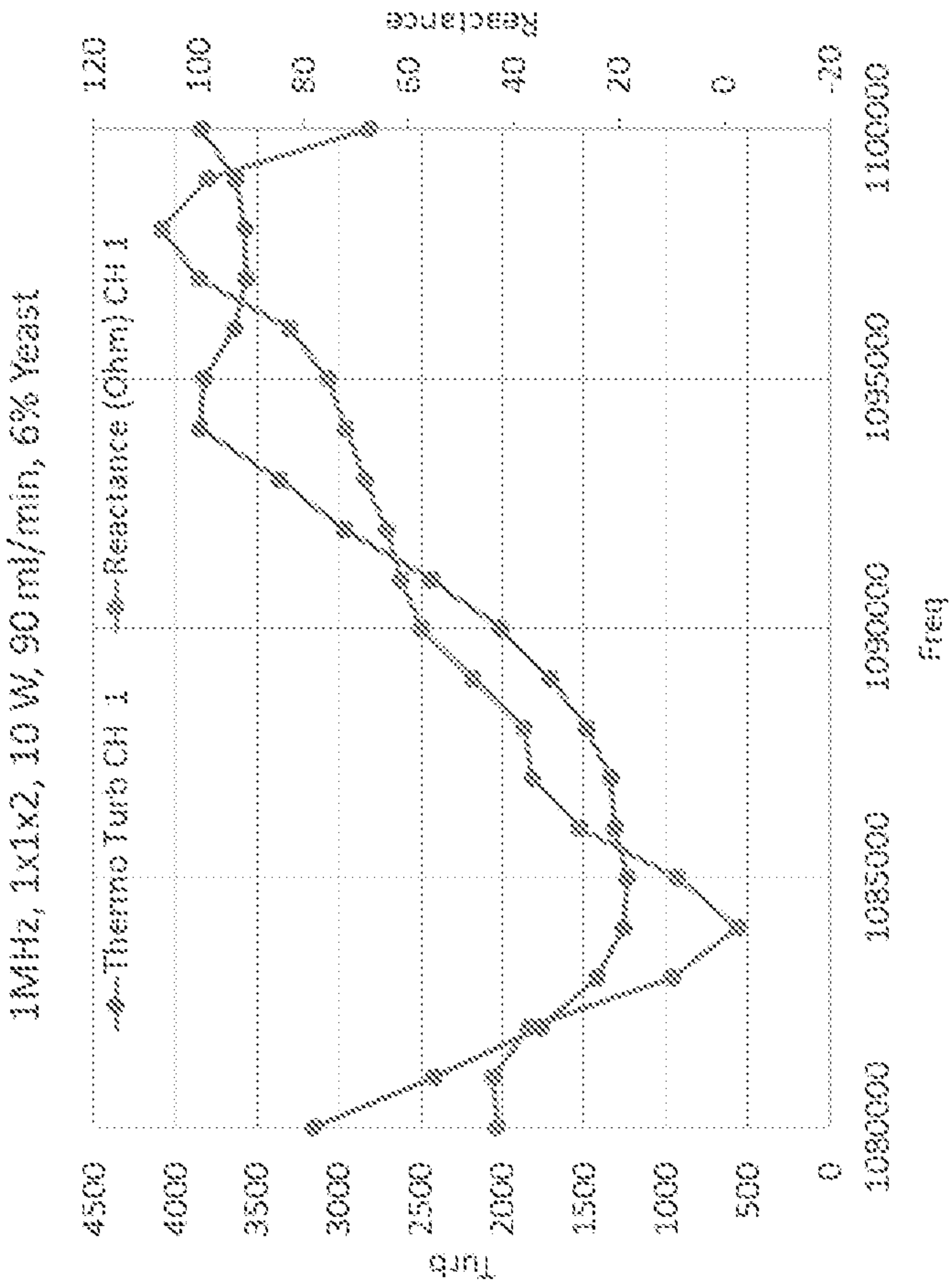


FIG. 62

- 1x1x2
- 6% Yeast
- 1 MHz
- 90 ml/min, 10W
- Each frequency ran for 20 minutes to reach a steady state
- Average values plotted

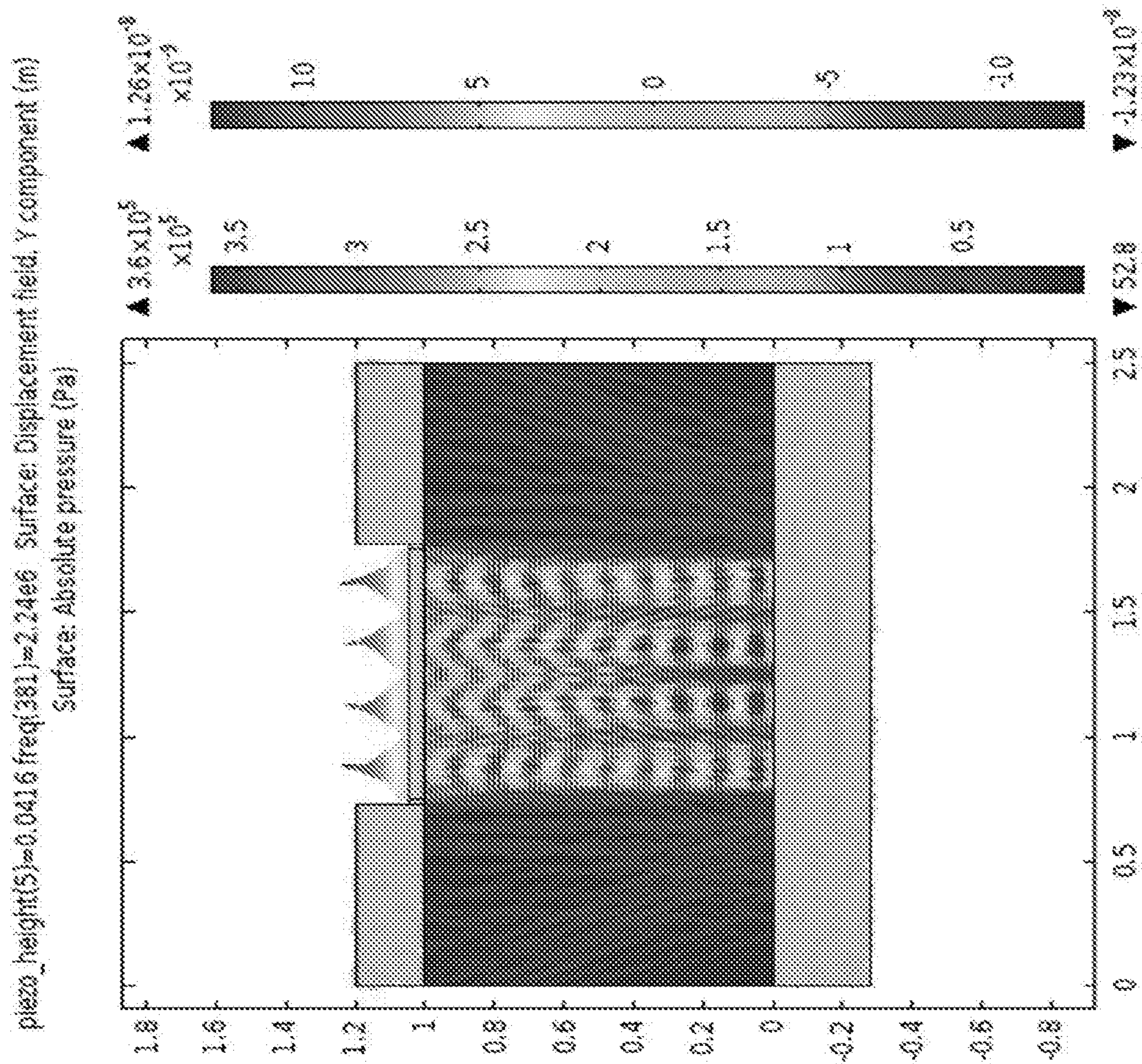


FIG. 63

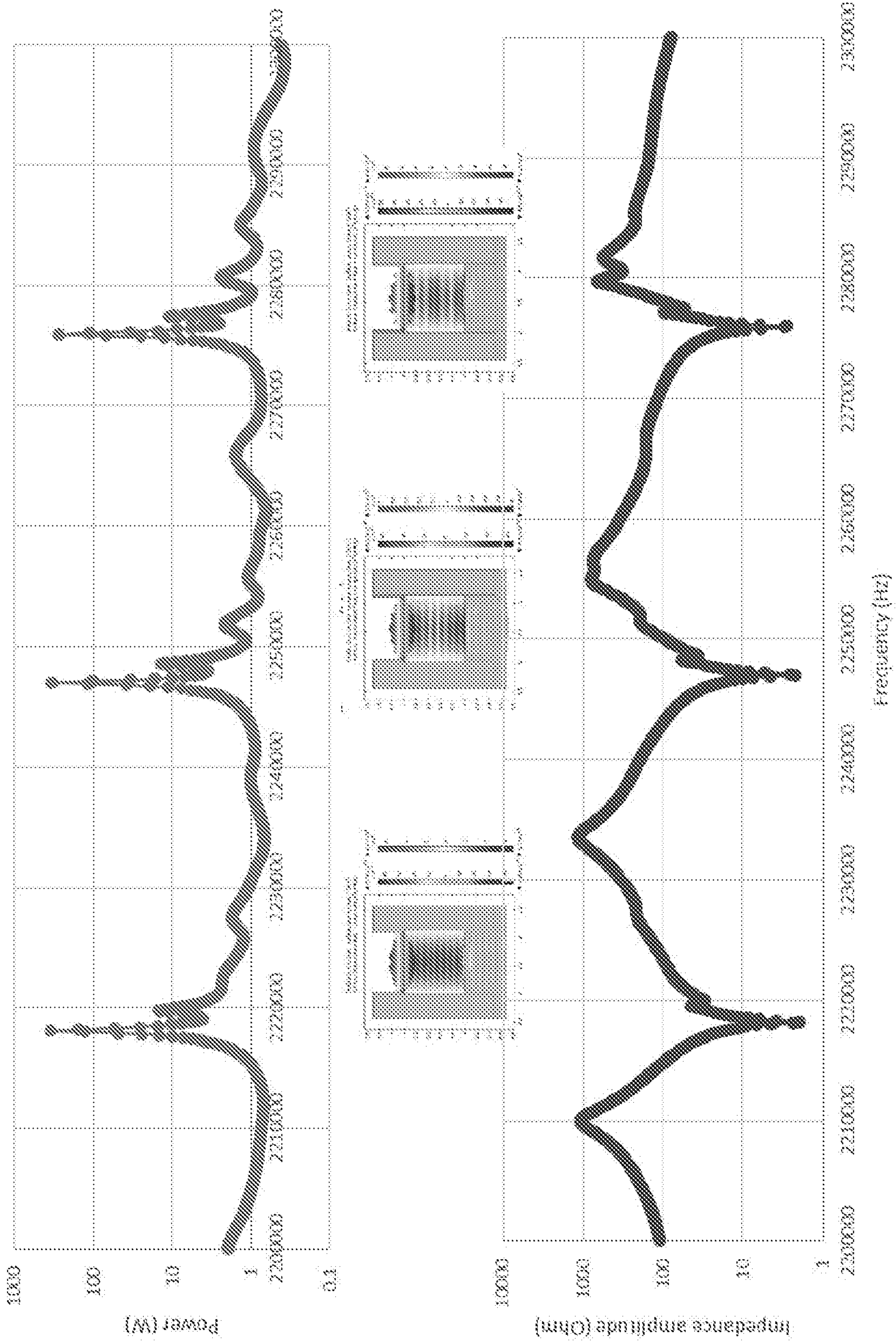


FIG. 64

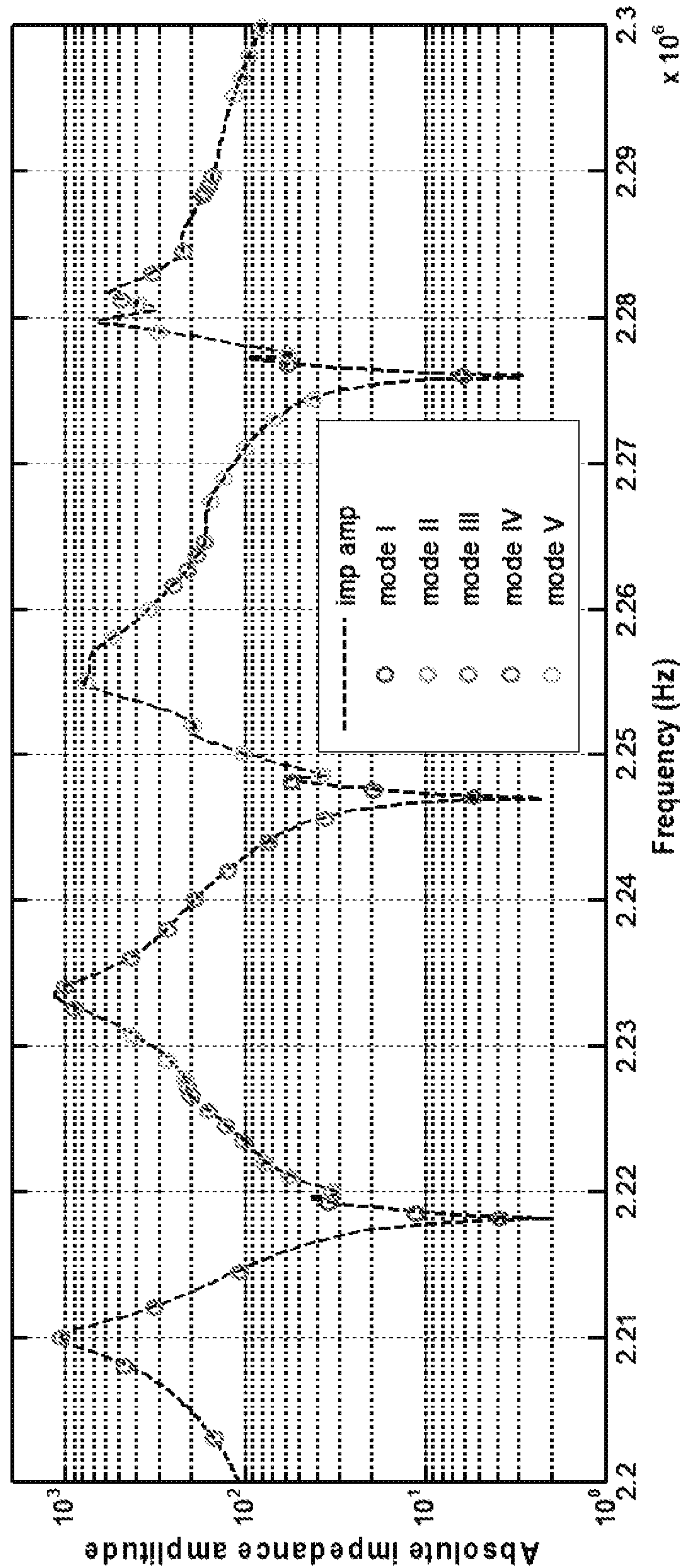


FIG. 65

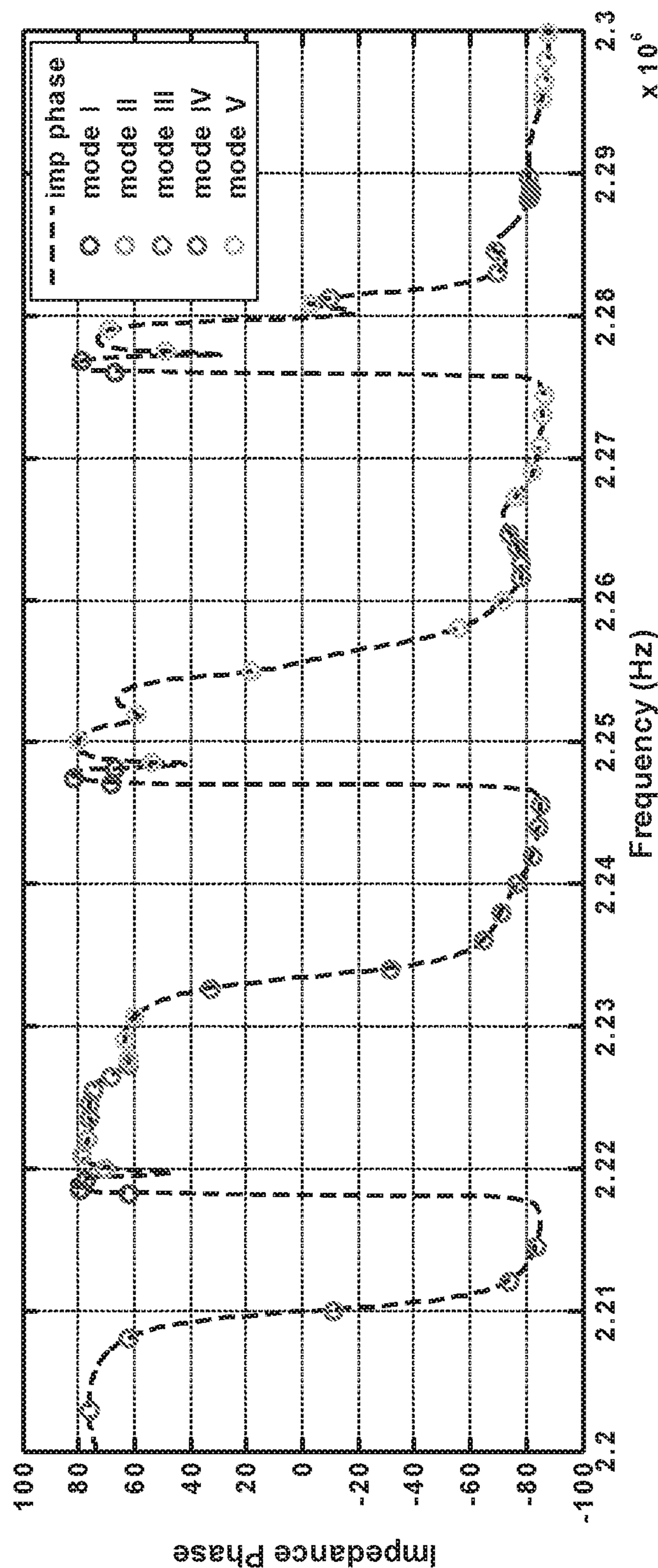


FIG. 66

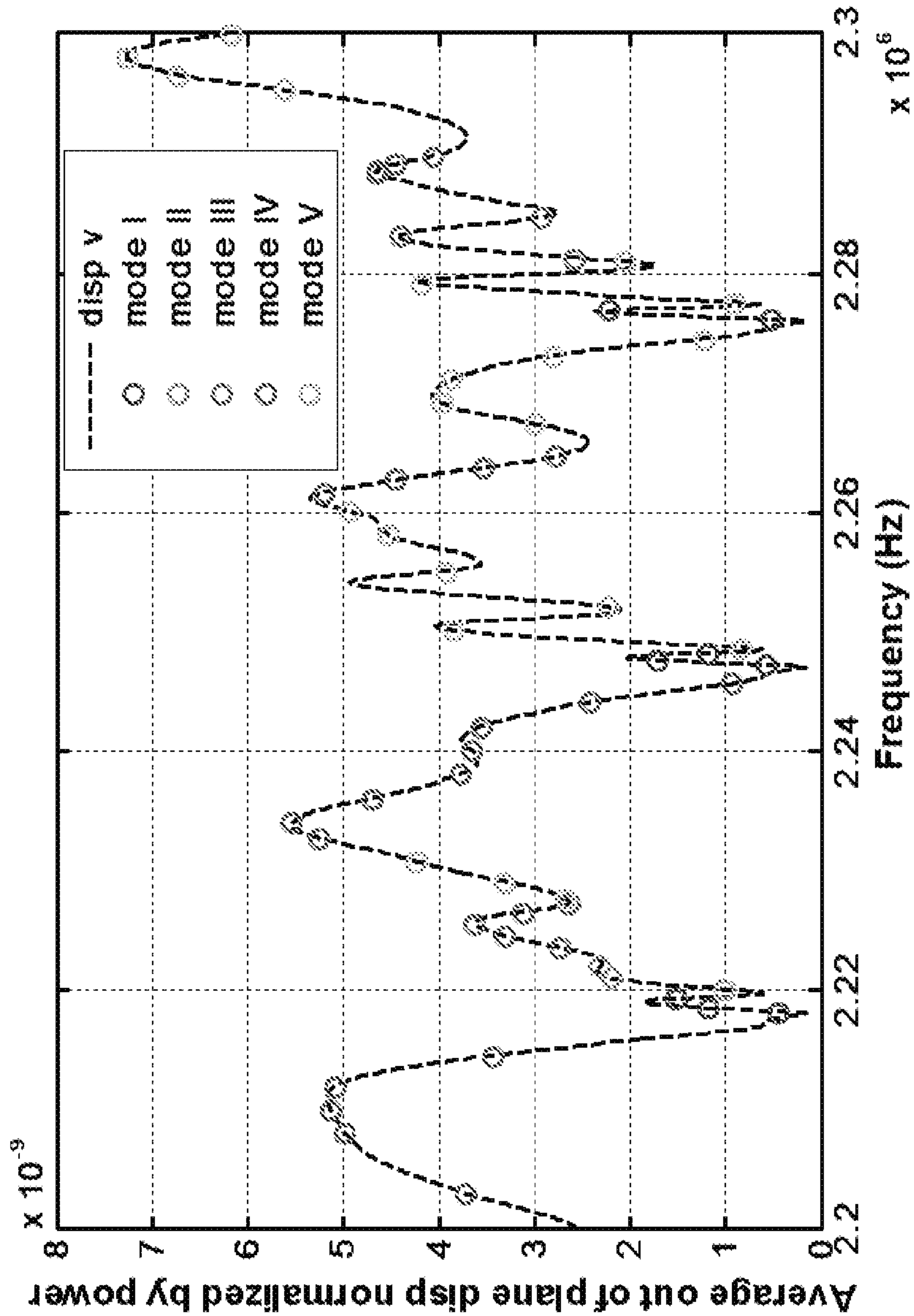


FIG. 67

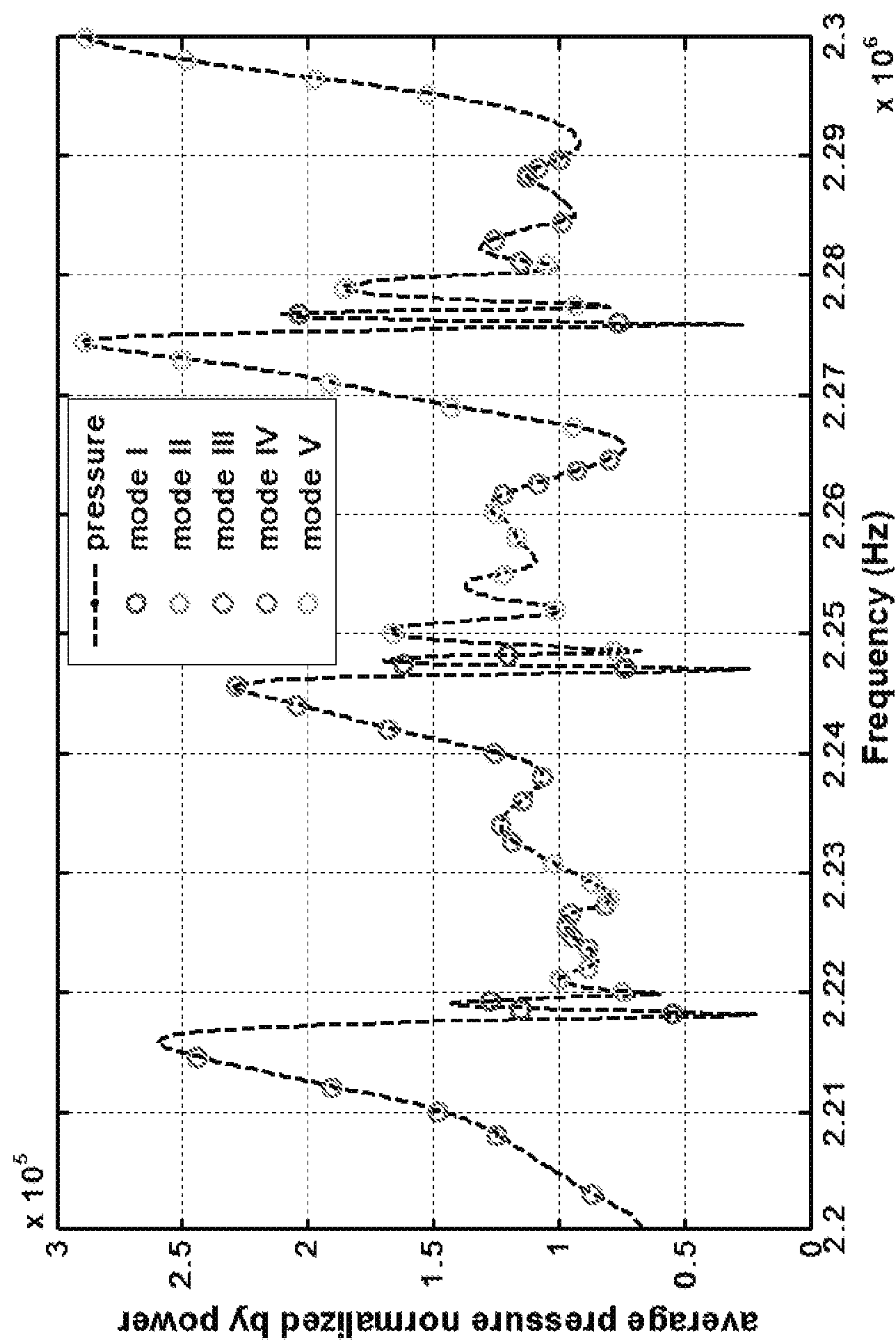


FIG. 68

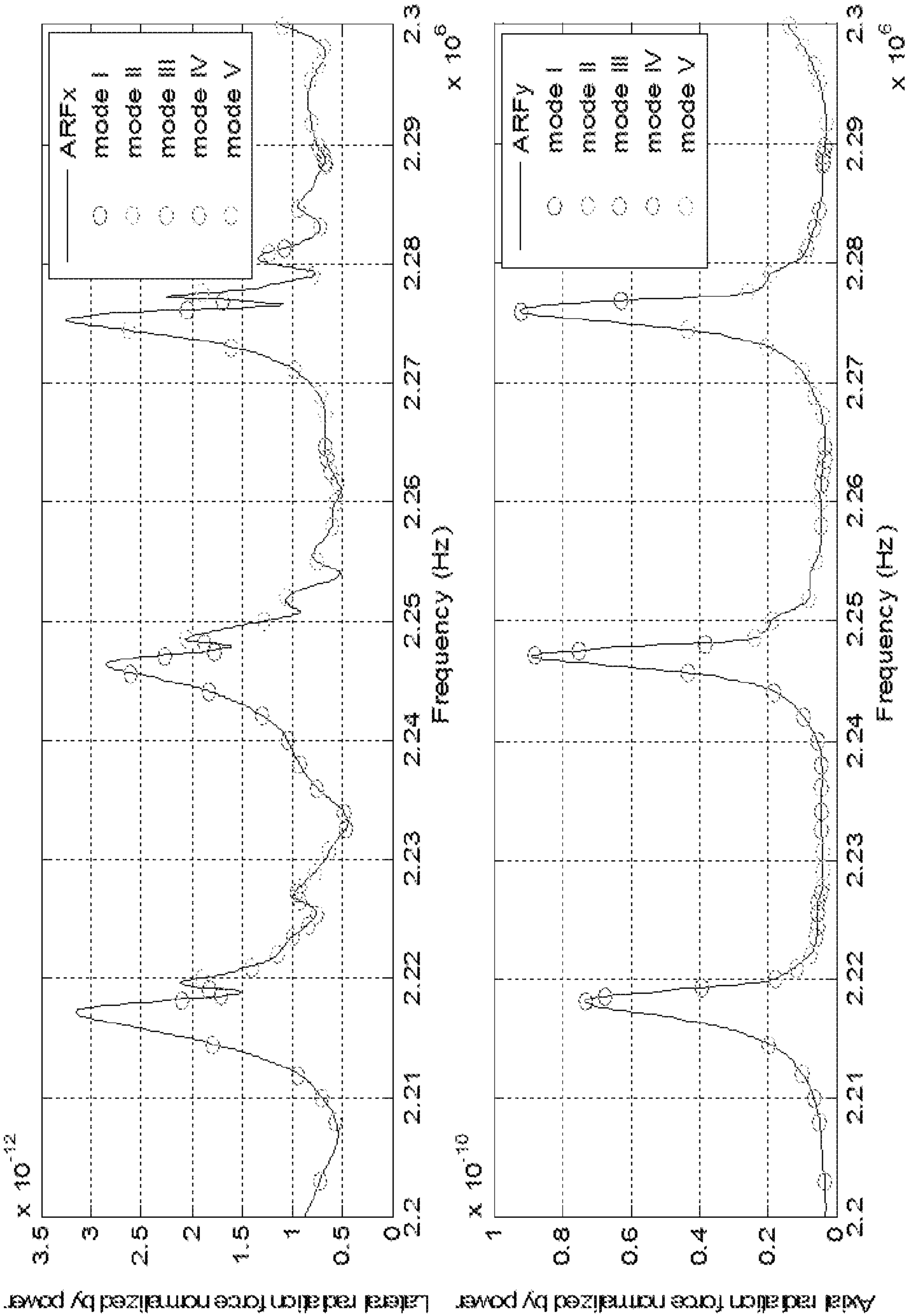


FIG. 69

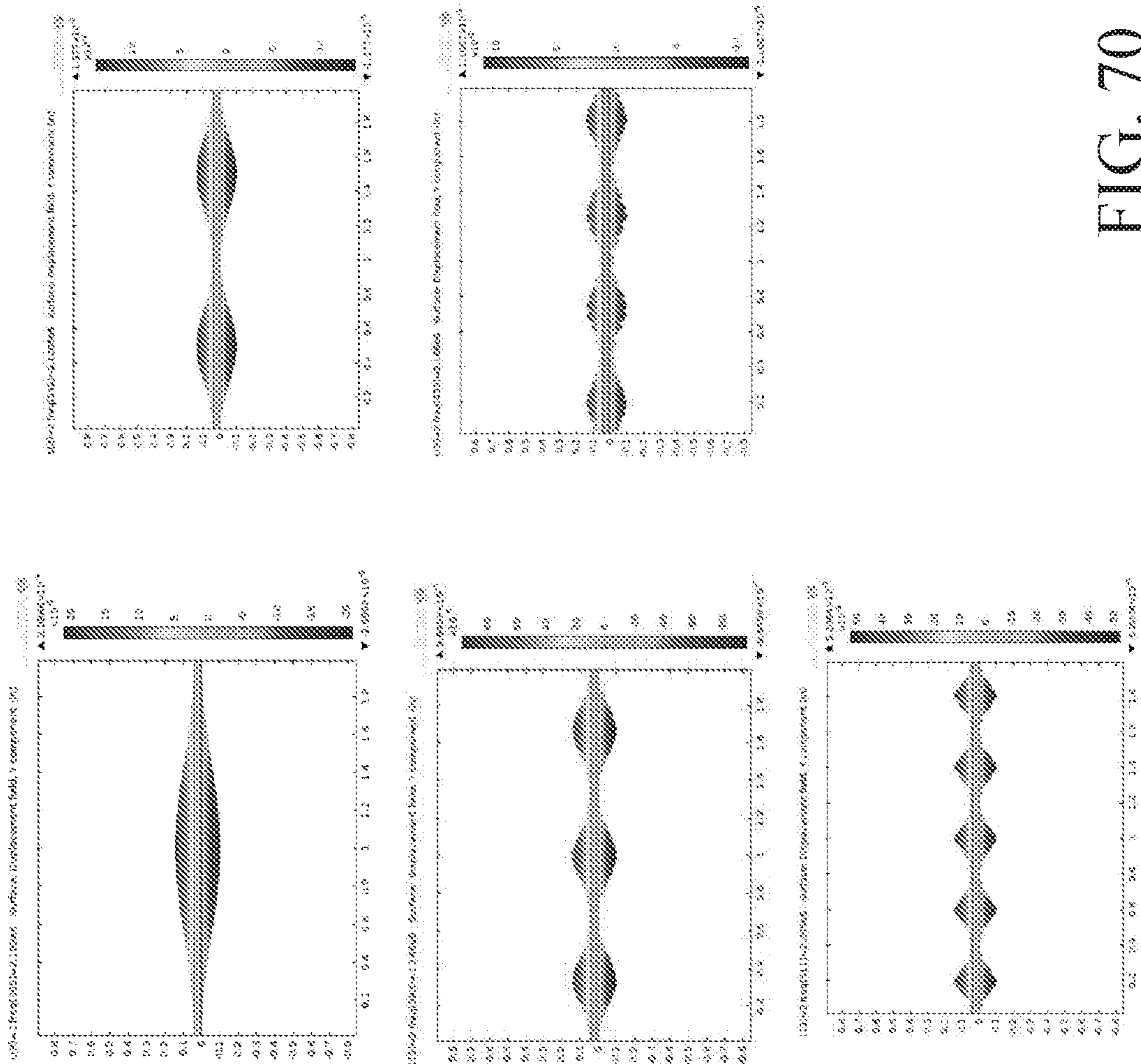


FIG. 70

Lamb Wave Dispersion Curve over Length
2 MHz PZT 8 Material

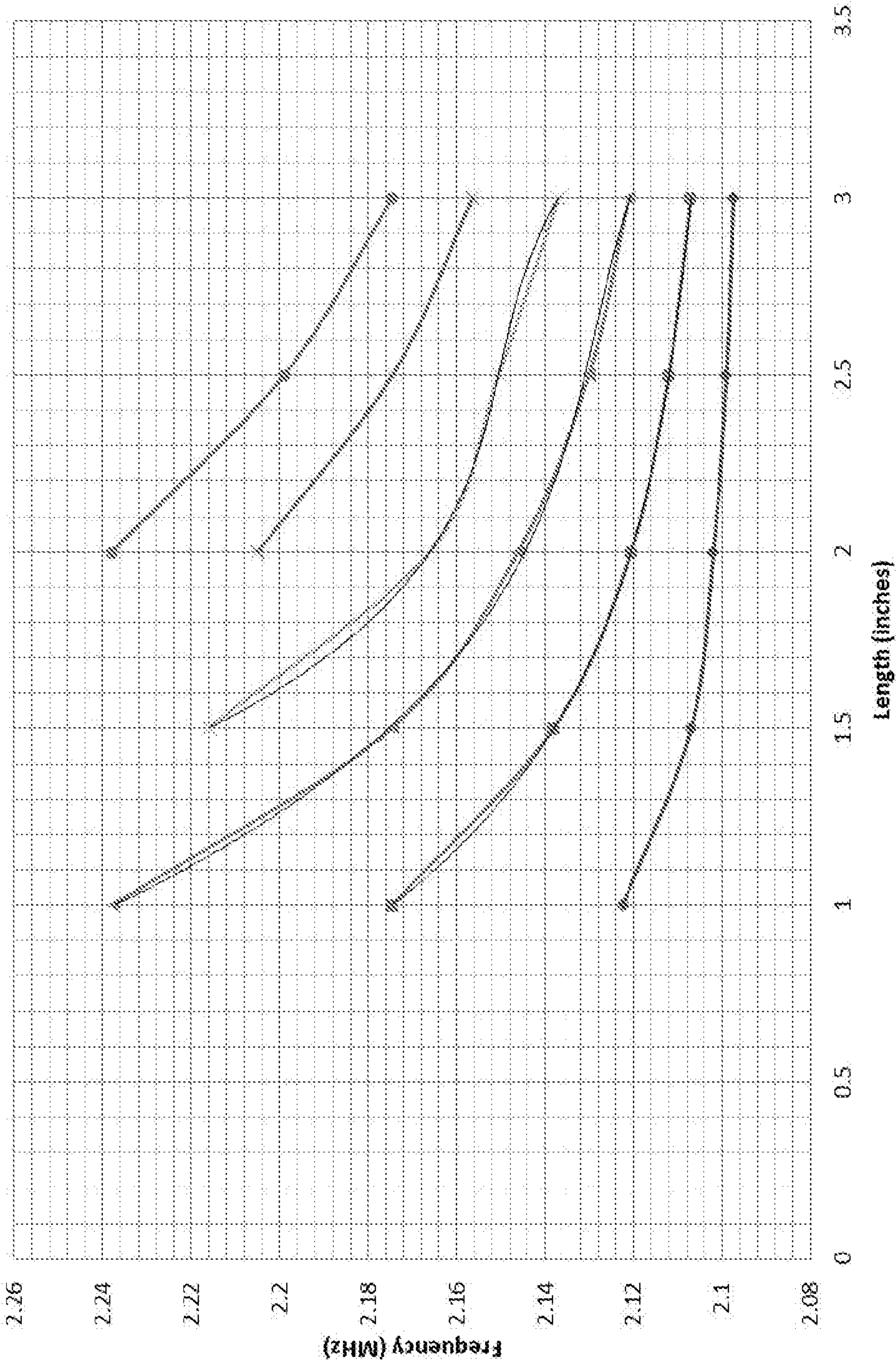


FIG. 71

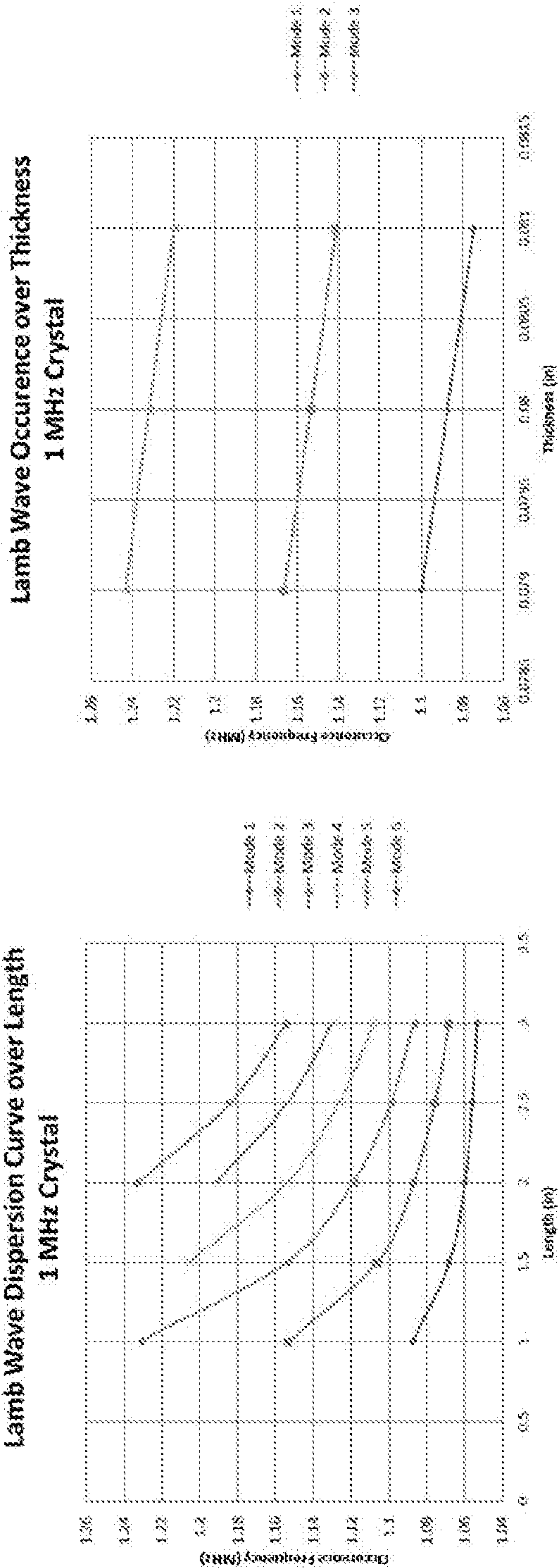


FIG. 72

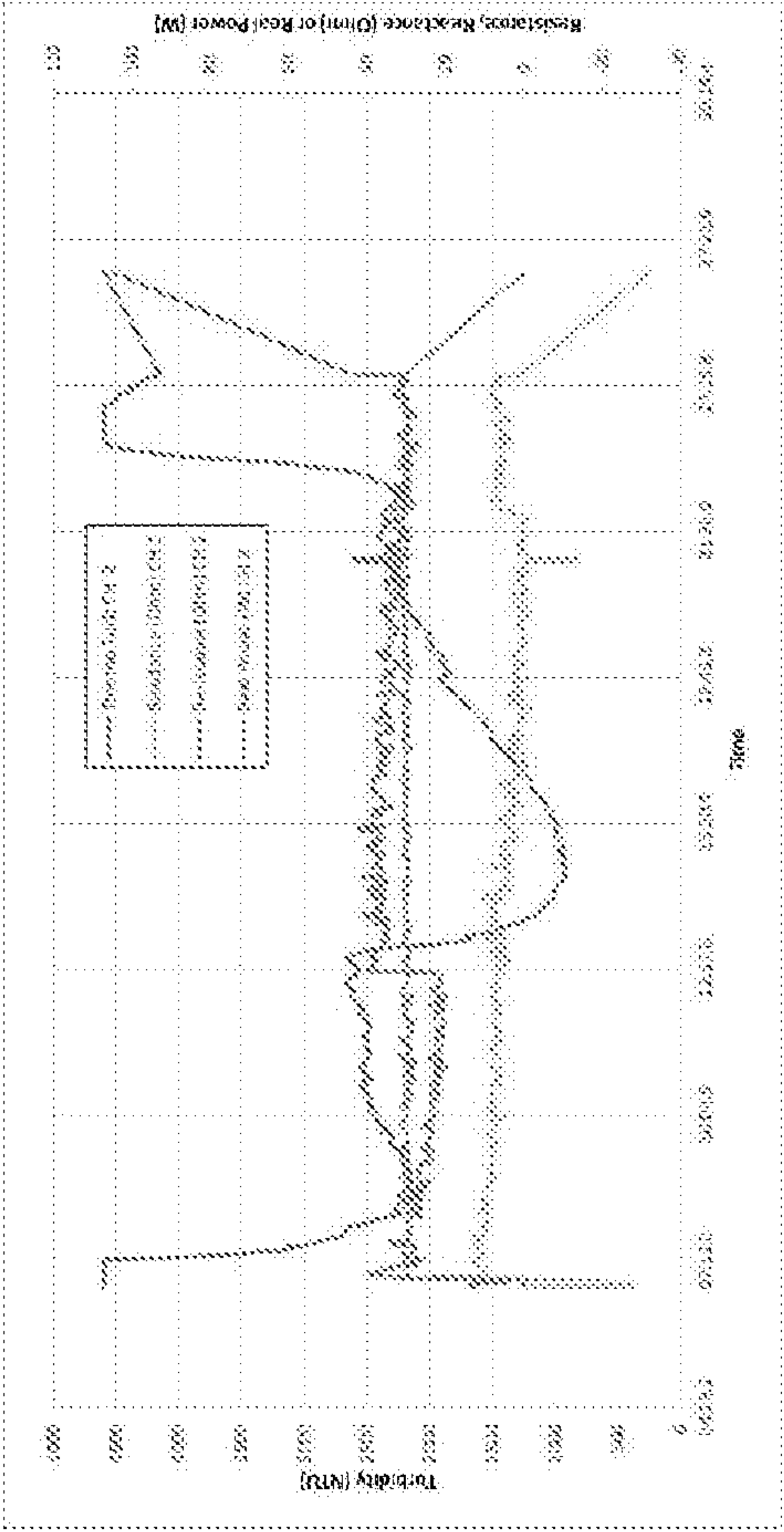


FIG. 73

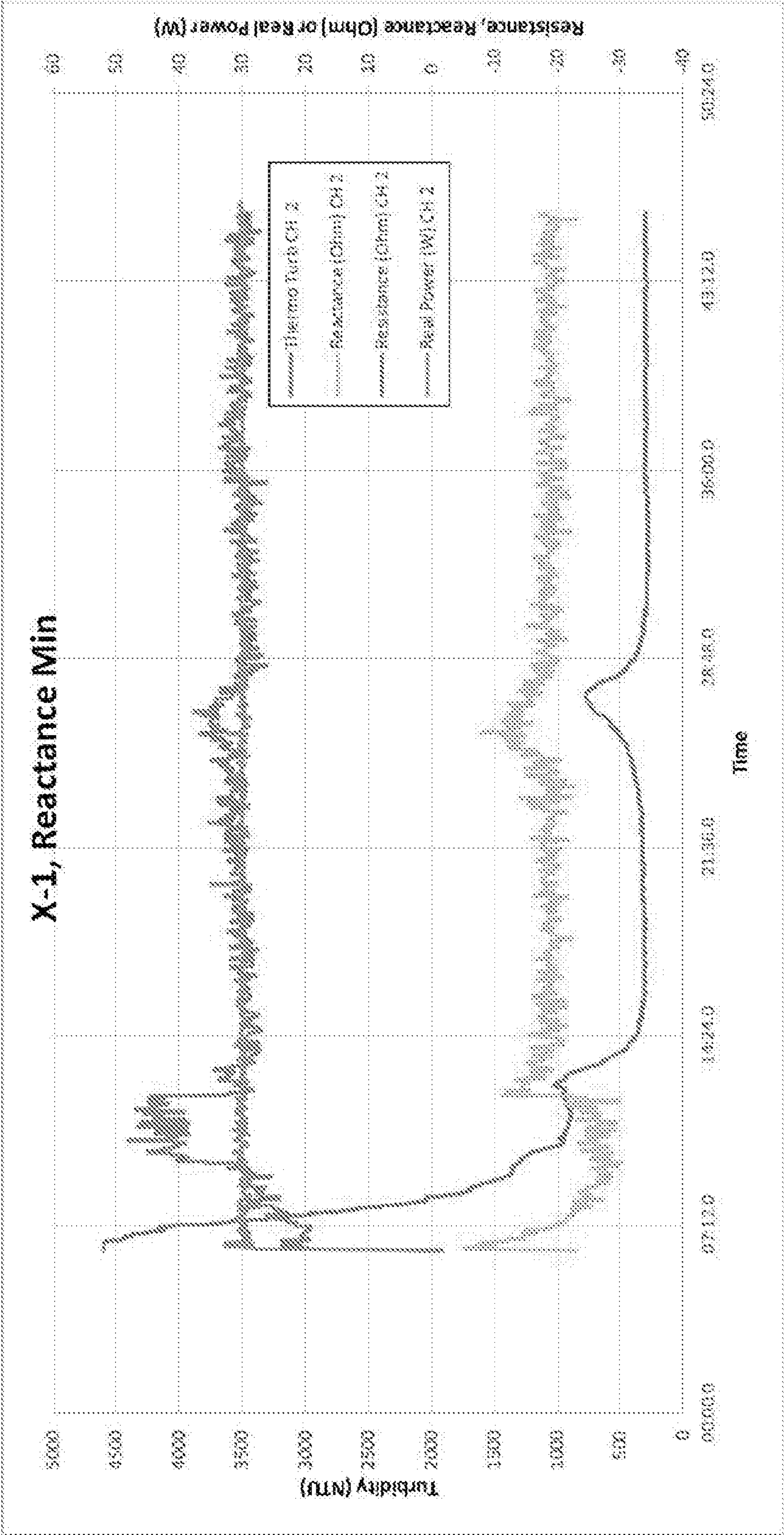


FIG. 74

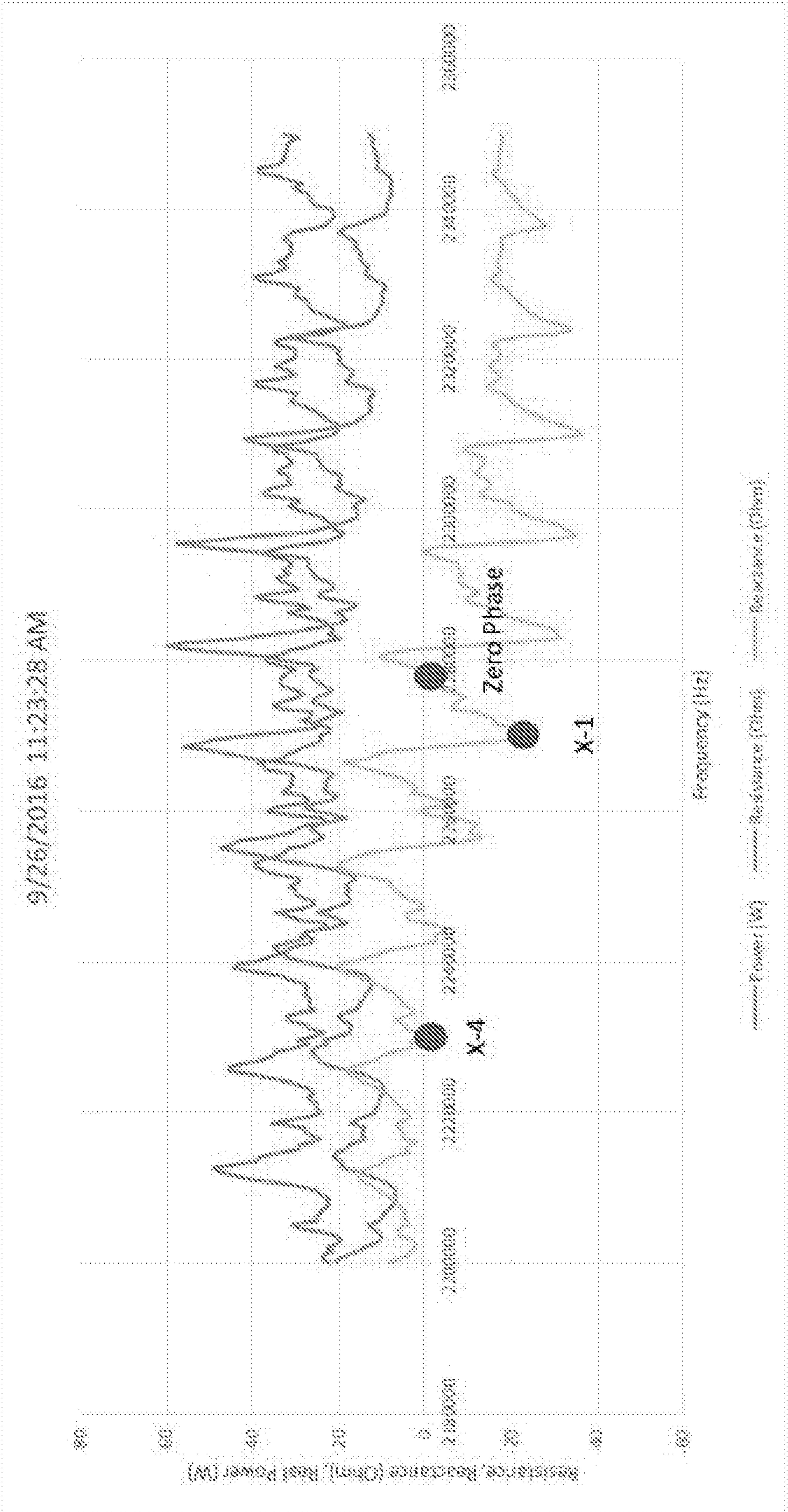


FIG. 75

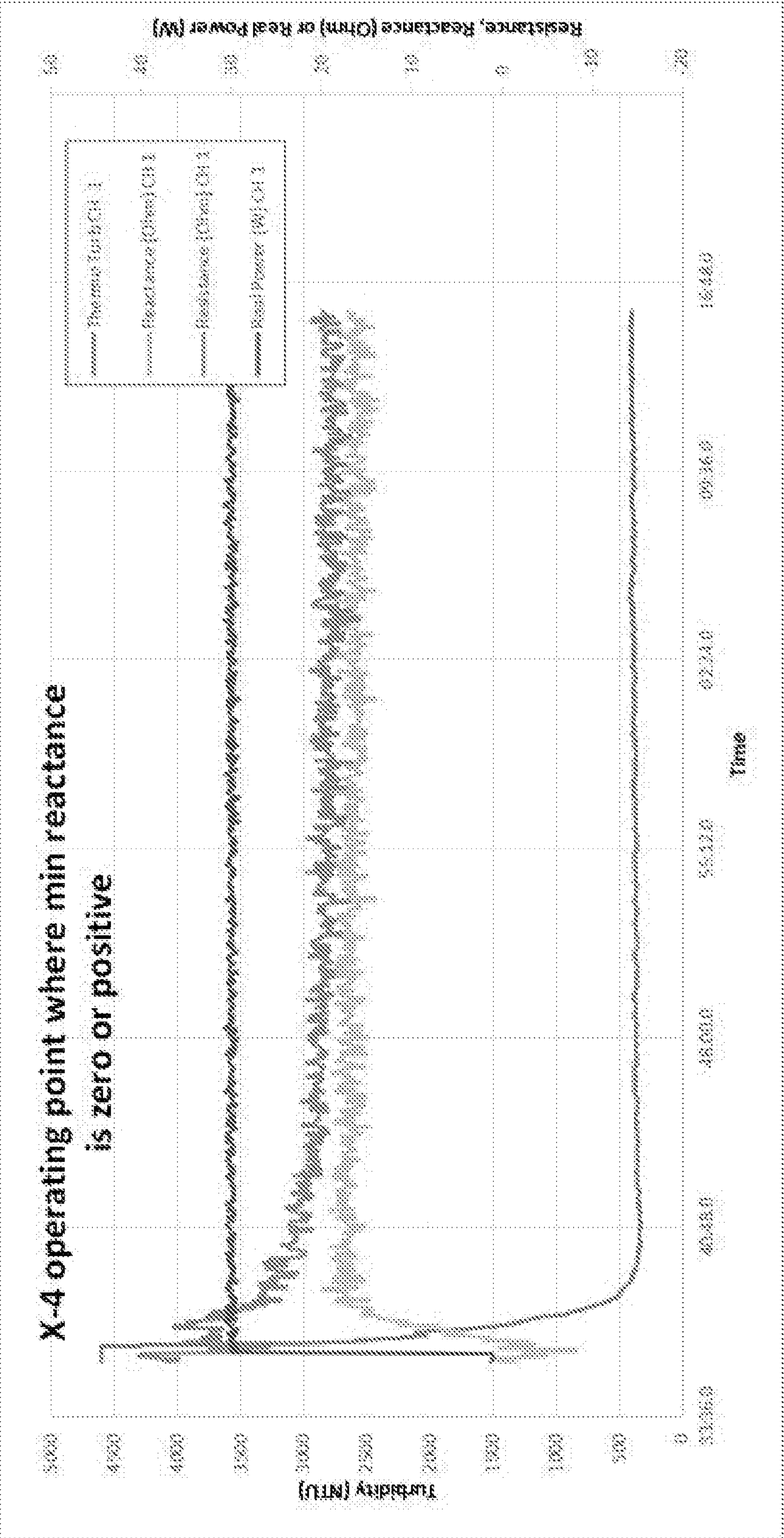


FIG. 76

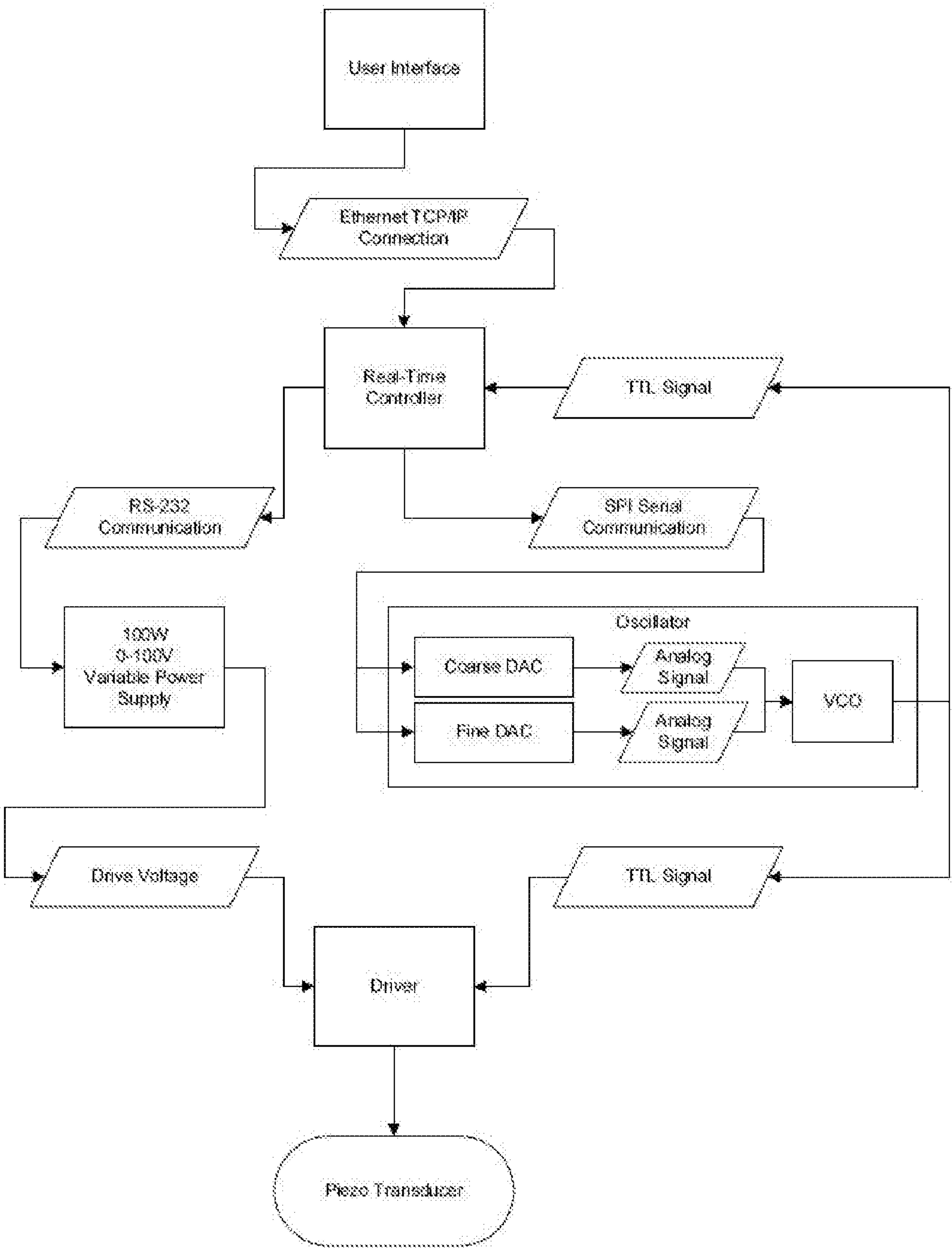


FIG. 77

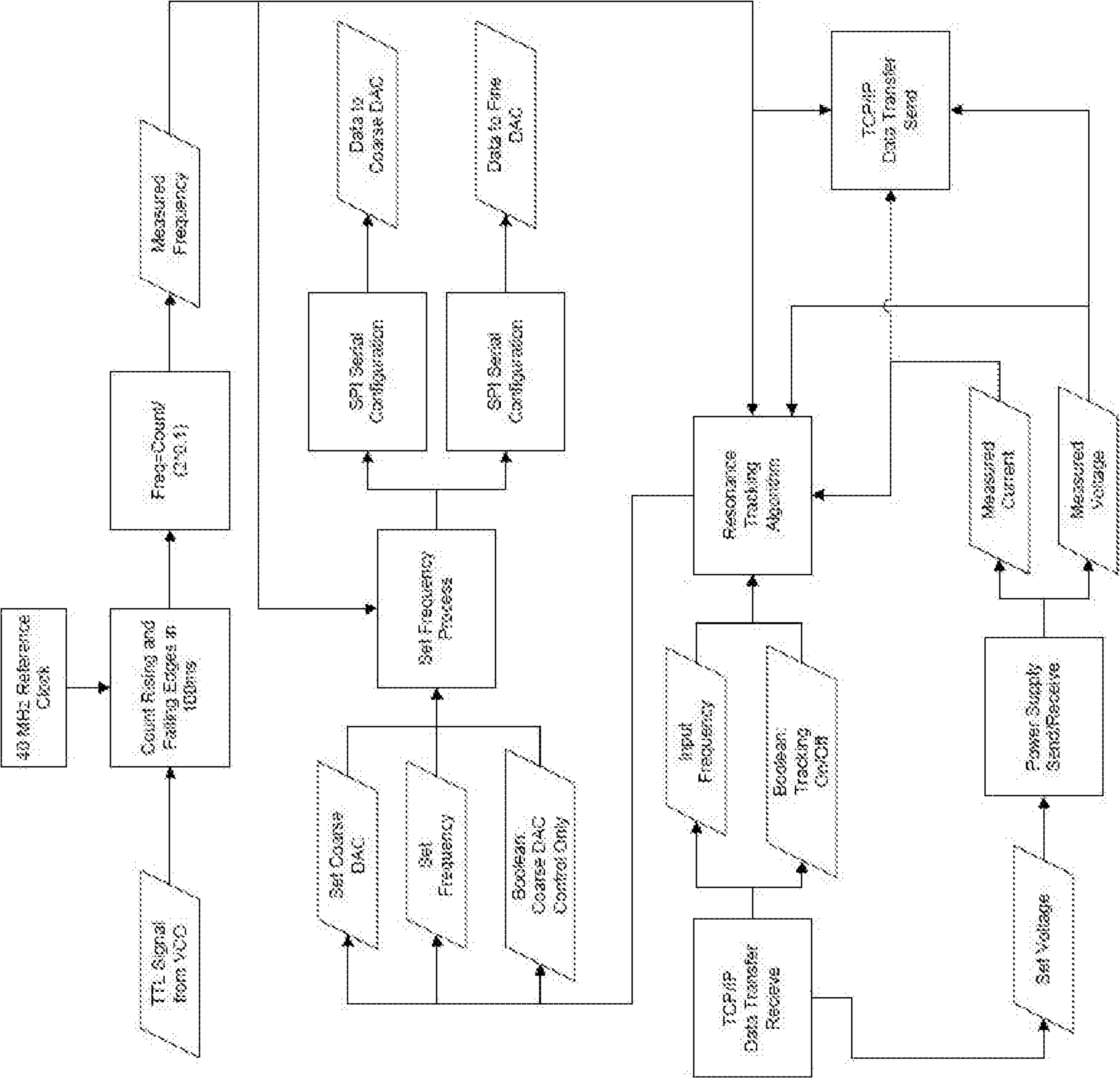


FIG. 78

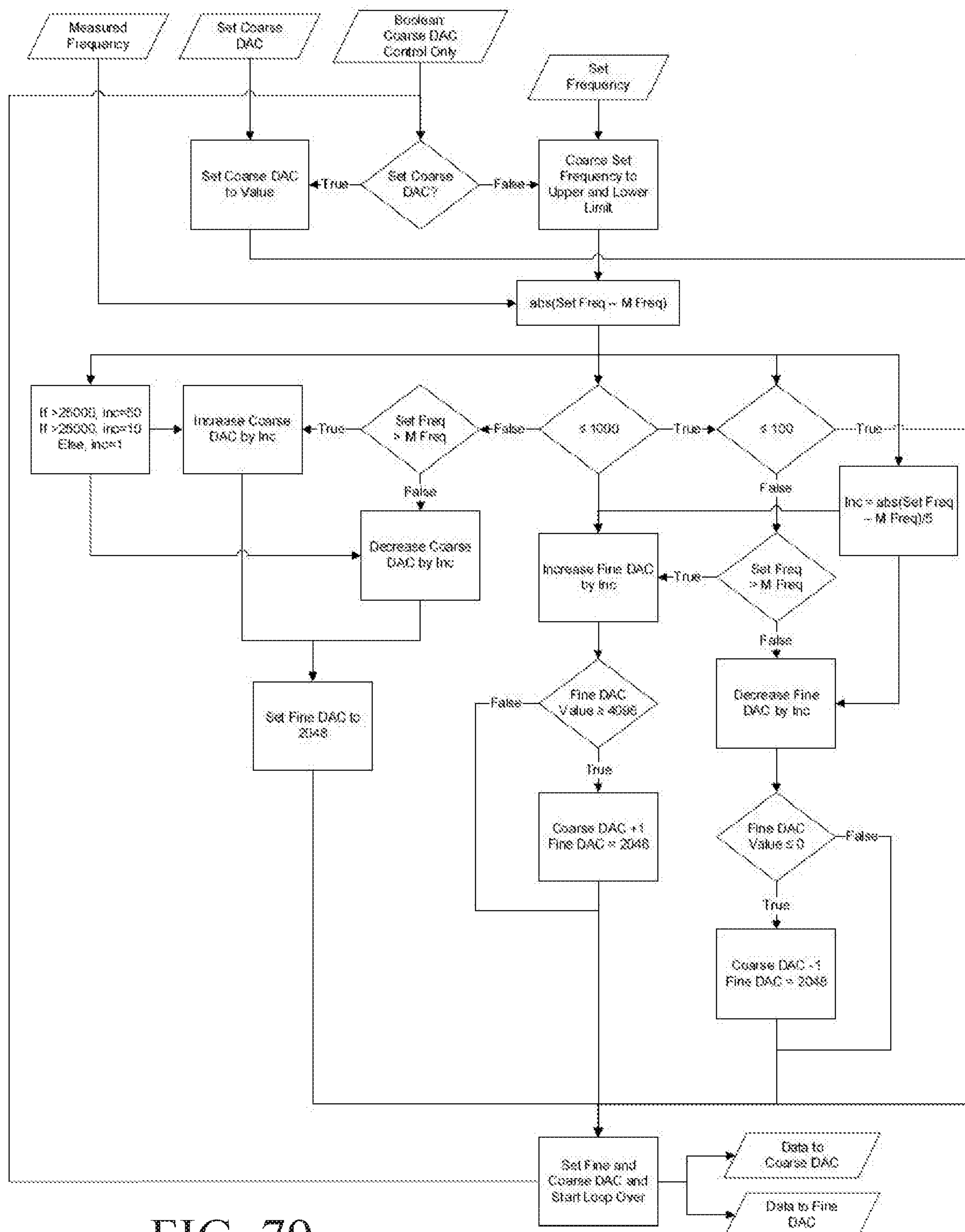


FIG. 79

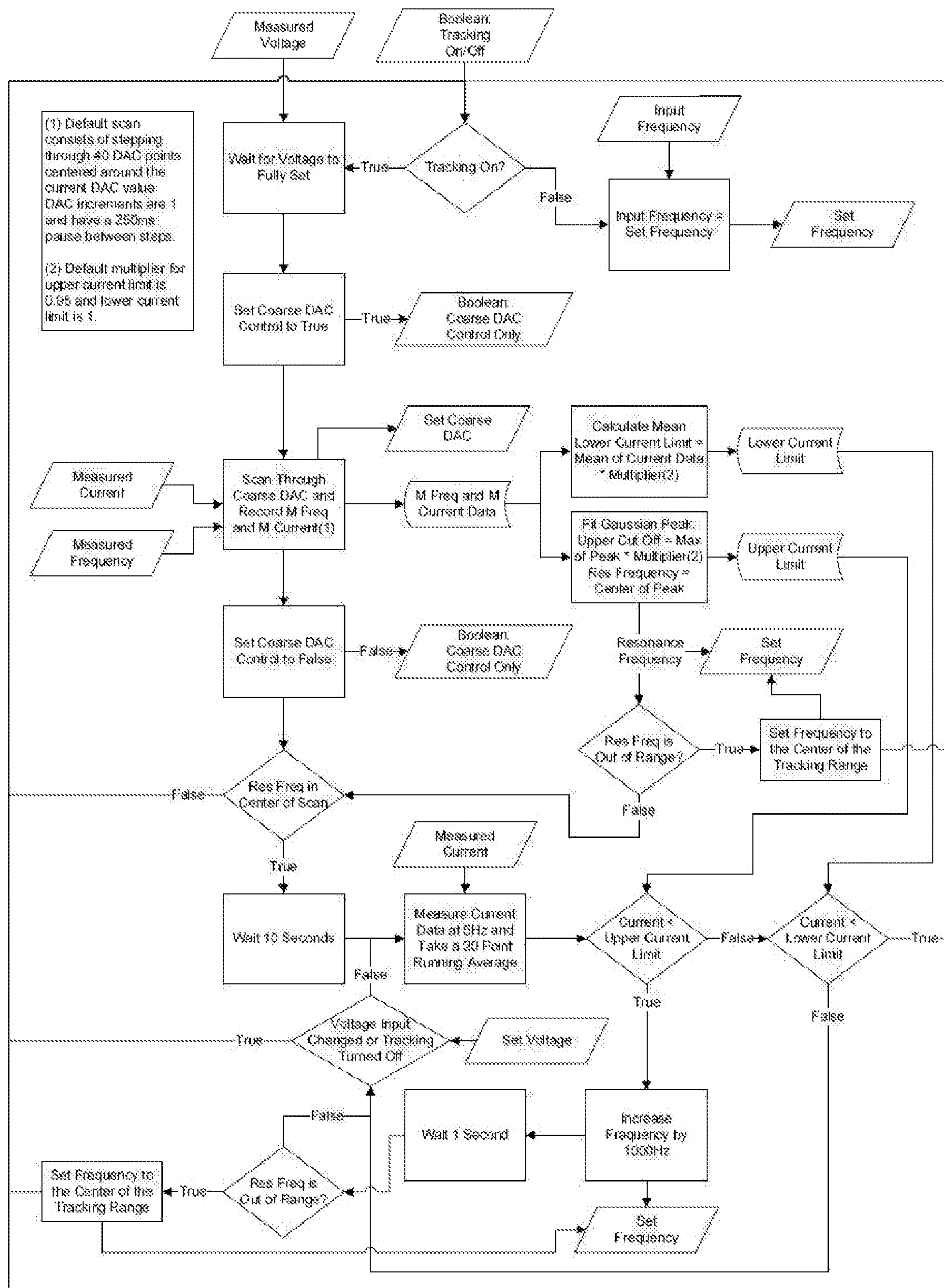


FIG. 80

Sweep Studies

- Sweep Settings
 - Range: 2.22 MHz – 2.26 MHz
 - Steps of 2 kHz
 - Held each freq for 5 mins
 - Constant 65V
- Measured AC values and seemed to correlate with DC readings
- Ran several studies on MM CHO and Yeast, both show max efficiency near max current

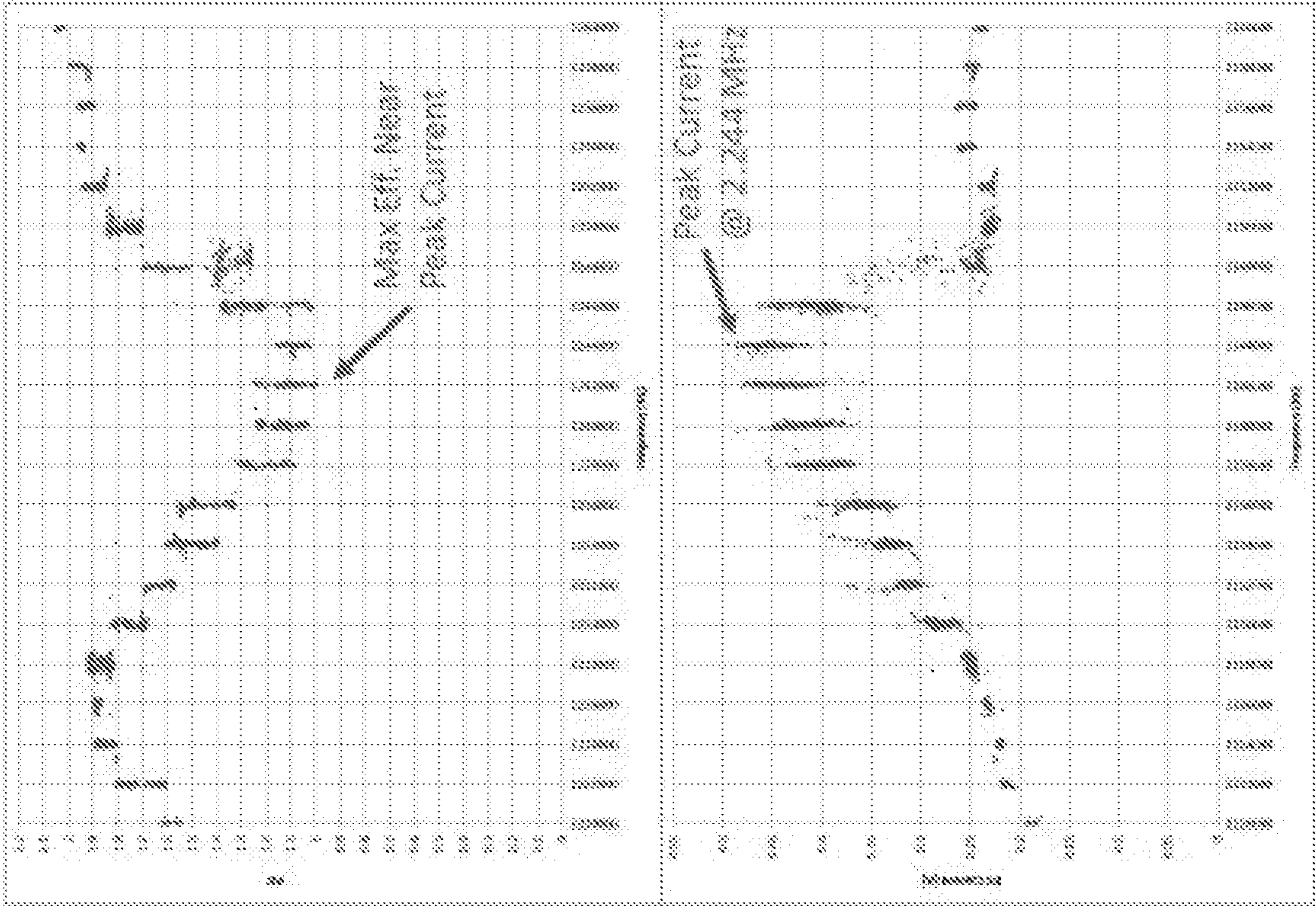


FIG. 81

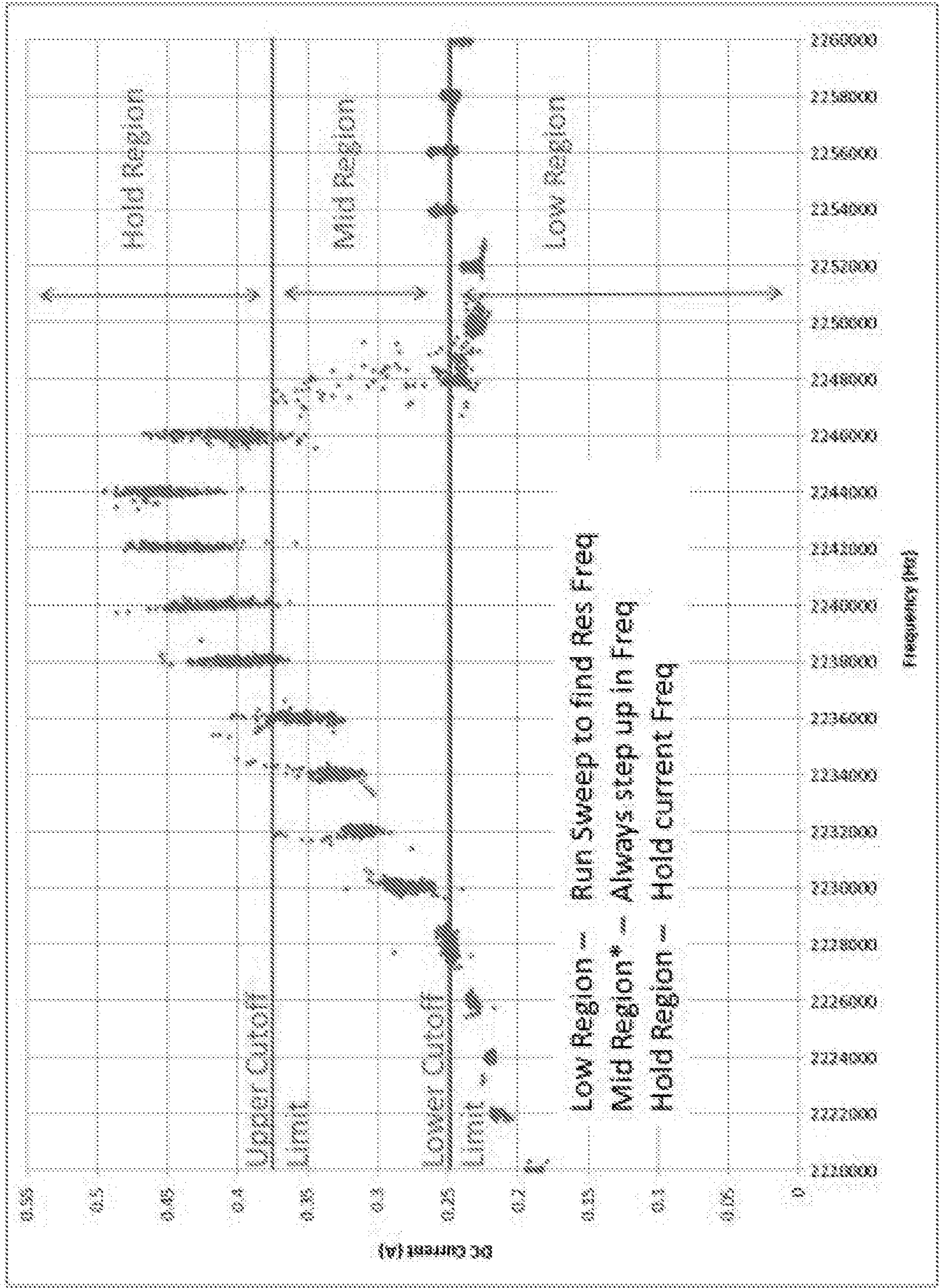


FIG. 82

How It Works

- When the transducer is powered on the voltage will ramp up to desired voltage
- When at desired voltage a frequency scan will commence
- Scan parameters
 - ~ Start- The bit word value on the coarse DAC is set to 20 units below the current value ~ -15kHz
 - ~ End- The bit word value on the coarse DAC is set to 20 units above the current value ~ +15kHz
 - ~ Increment- 1 bit word value on the coarse DAC ~ 1kHz
 - ~ Step Duration- 250 ms
 - ~ Total Duration- 10 seconds
- Current and frequency data is used to fit a Gaussian Peak
 - ~ Frequency center of peak is resonance frequency
 - ~ 95% of peak is set to Upper Cutoff Limit
 - ~ Average of all current data from scan is Lower Cutoff Limit

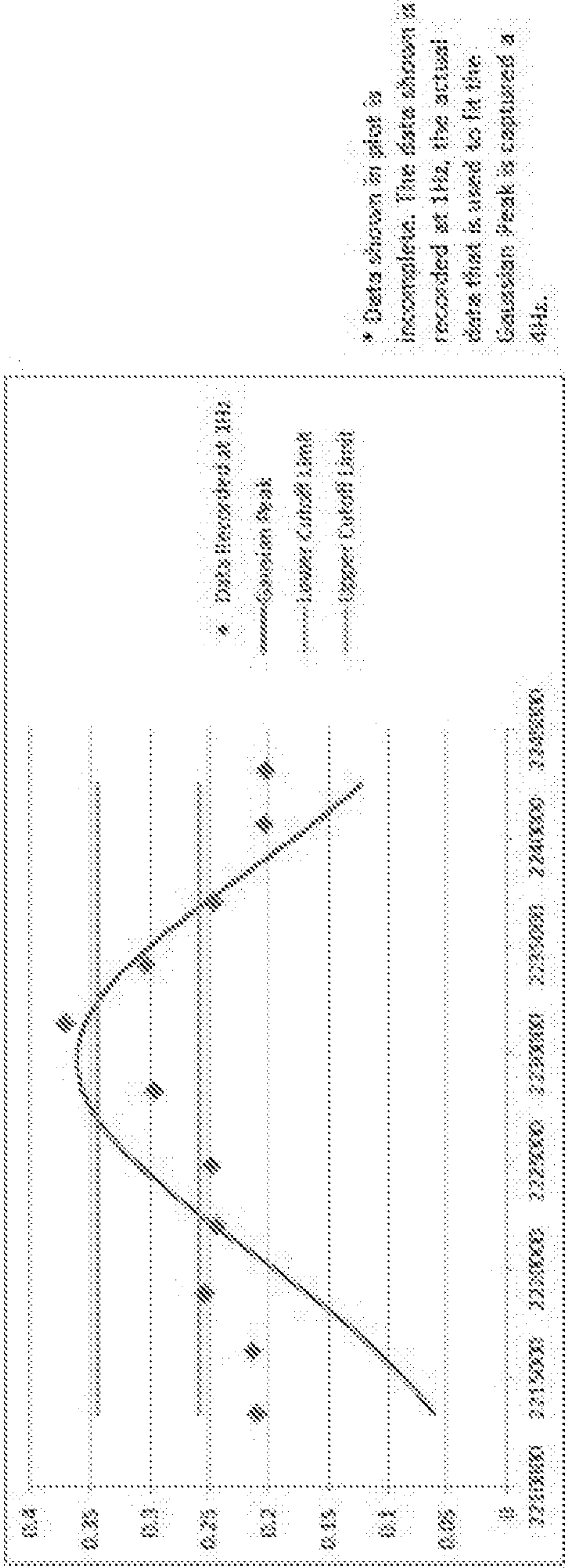


FIG. 83

How It Works

- After the scan, the system will set the frequency to the resonance frequency and wait 10 seconds before monitoring.
- Current data is continually monitored at 5Hz and a running average of 20 points is calculated
 - If the running average stays above the Upper Cutoff Limit, the system will continue to monitor
 - If the running average drops below the Upper Cutoff Limit, the frequency is increased by 1000Hz
 - If the running average drops below the Lower Cutoff Limit, a scan is commenced
- Frequency can be changed at any point. The system will change the frequency, wait 10 seconds, and continue monitoring at the new frequency
- When the voltage is changed a new scan will be initiated
- Tracking range is set from 2.2 MHz to 2.26 MHz
 - If tracking algorithm moves frequency out of this range, it resets the frequency to 2.23 MHz

FIG. 84

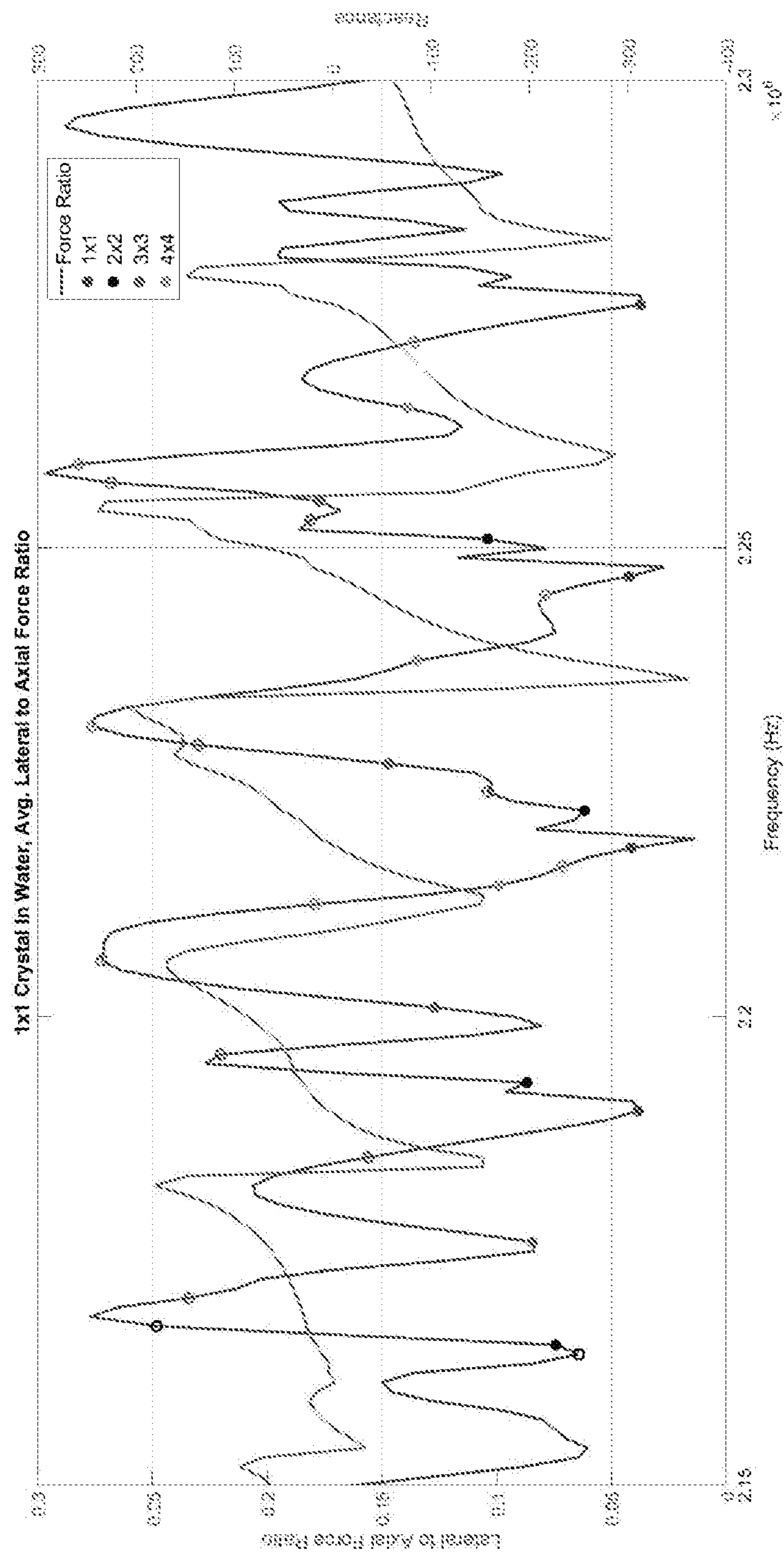


FIG. 85

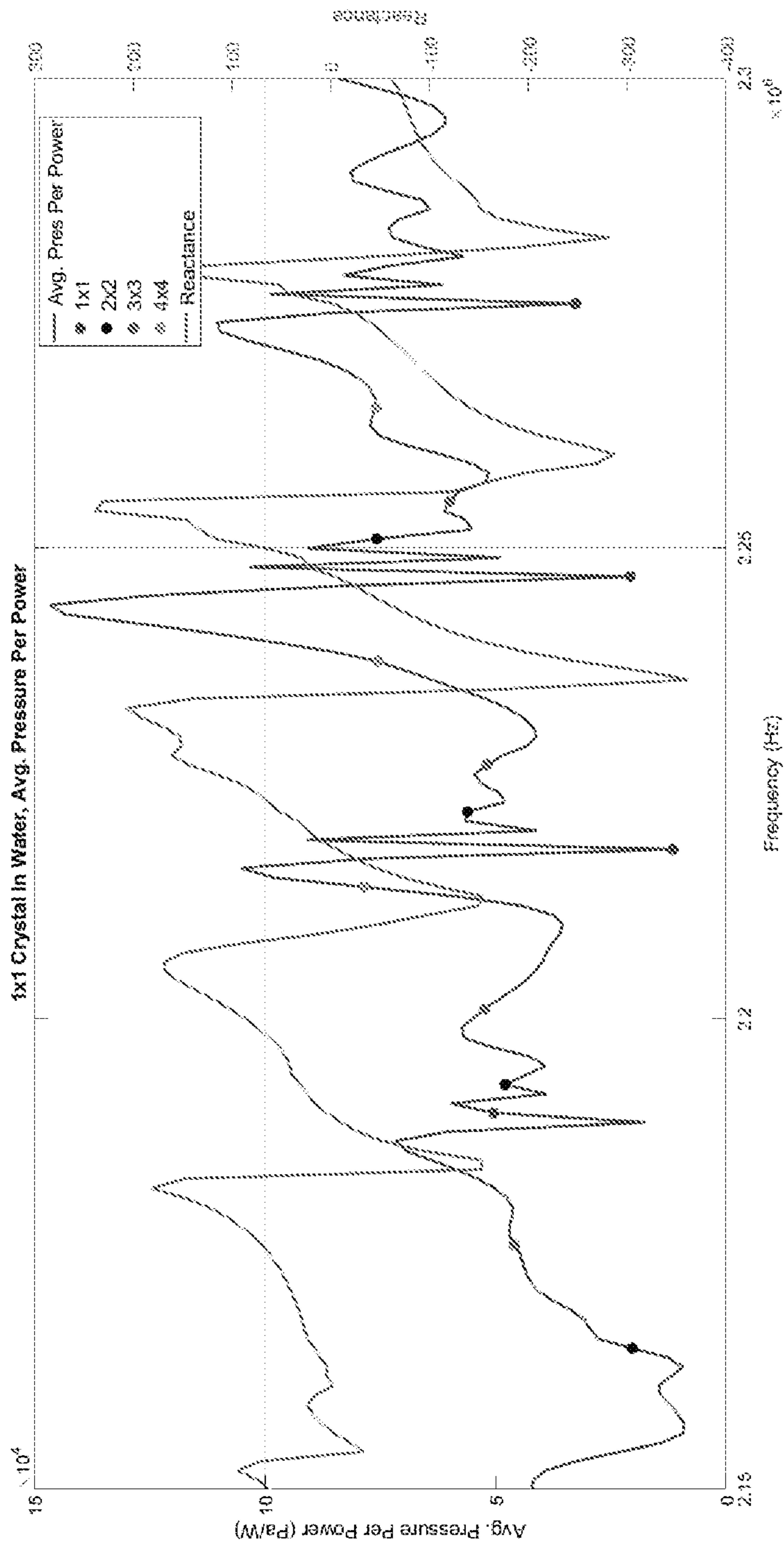


FIG. 86

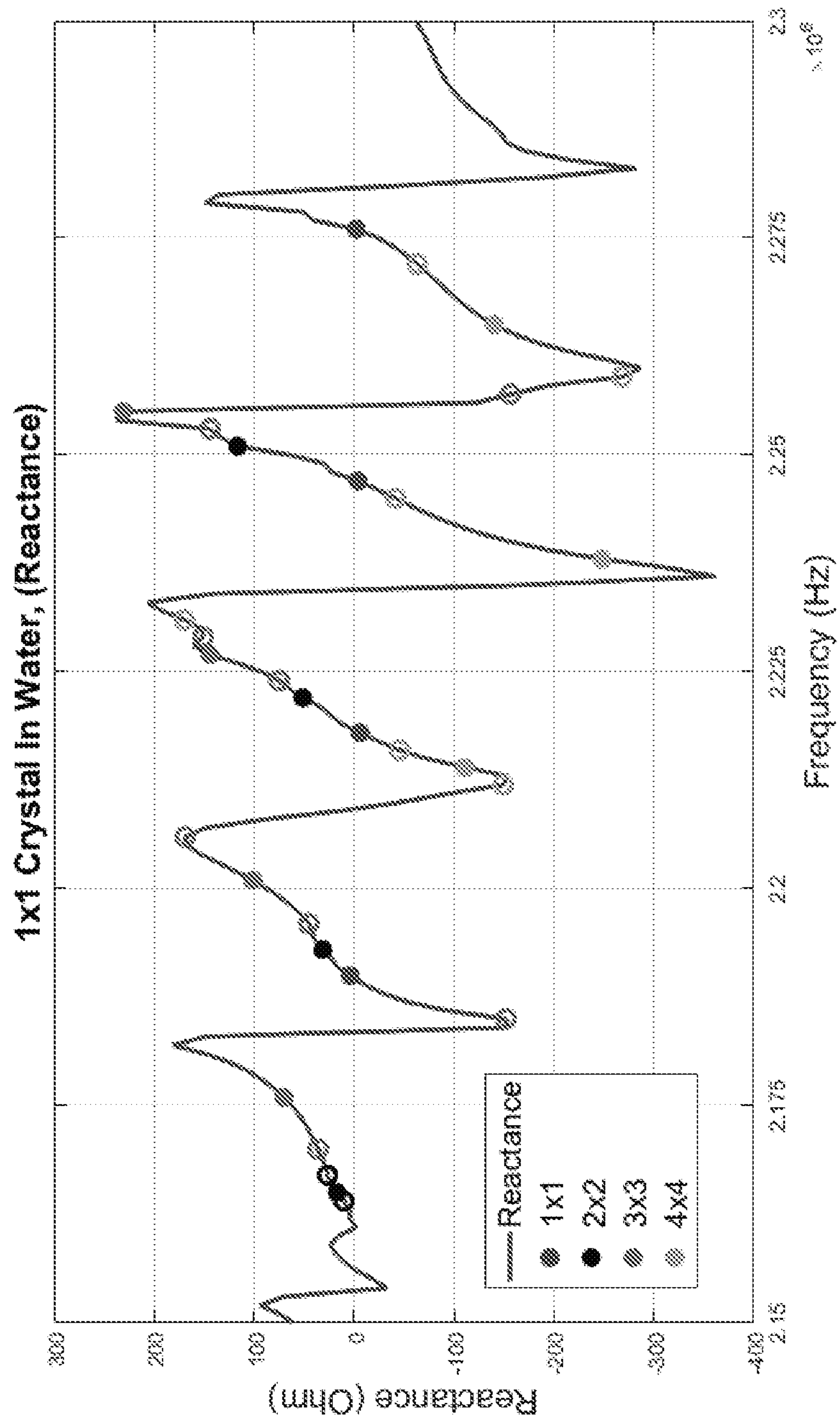


FIG. 87

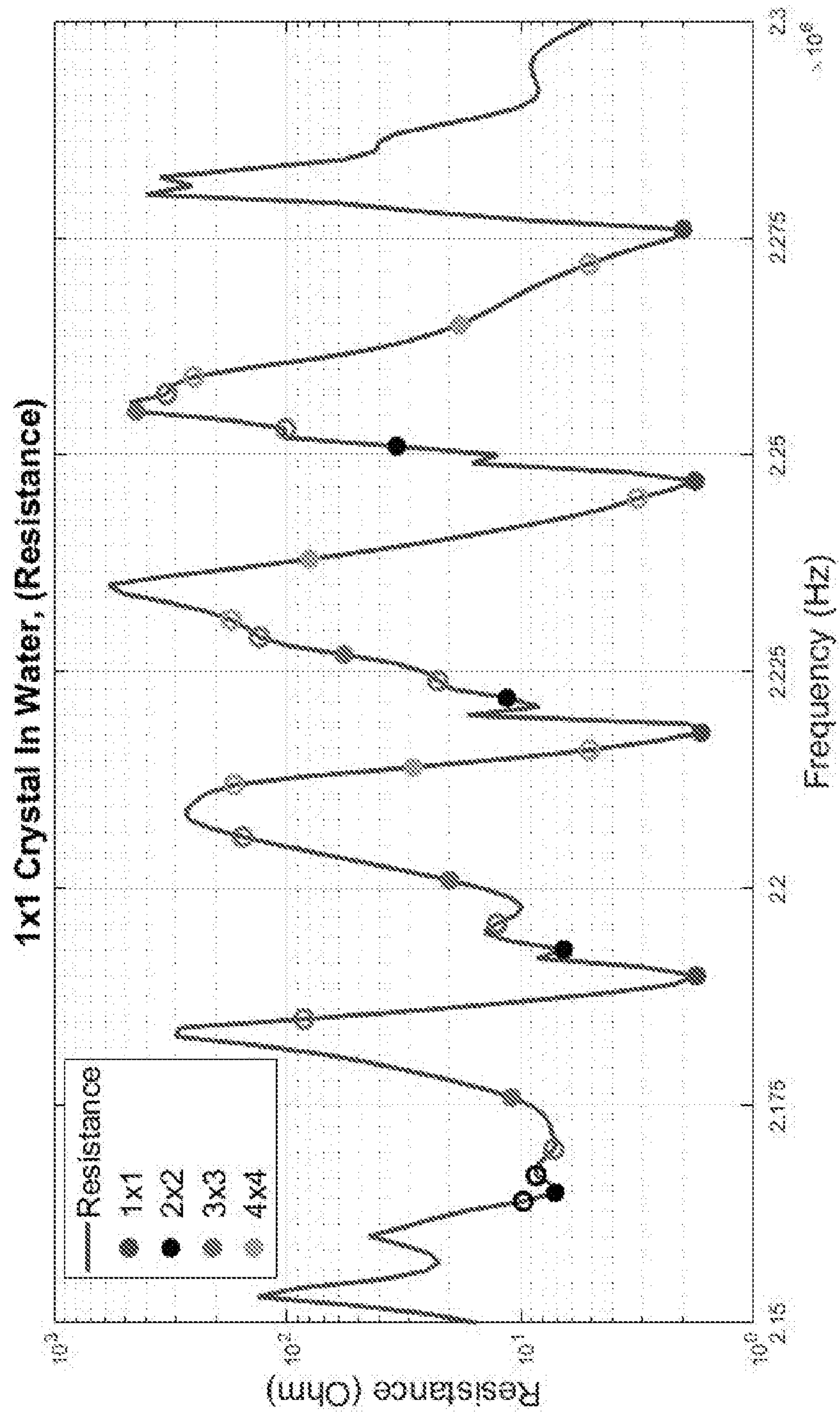


FIG. 88

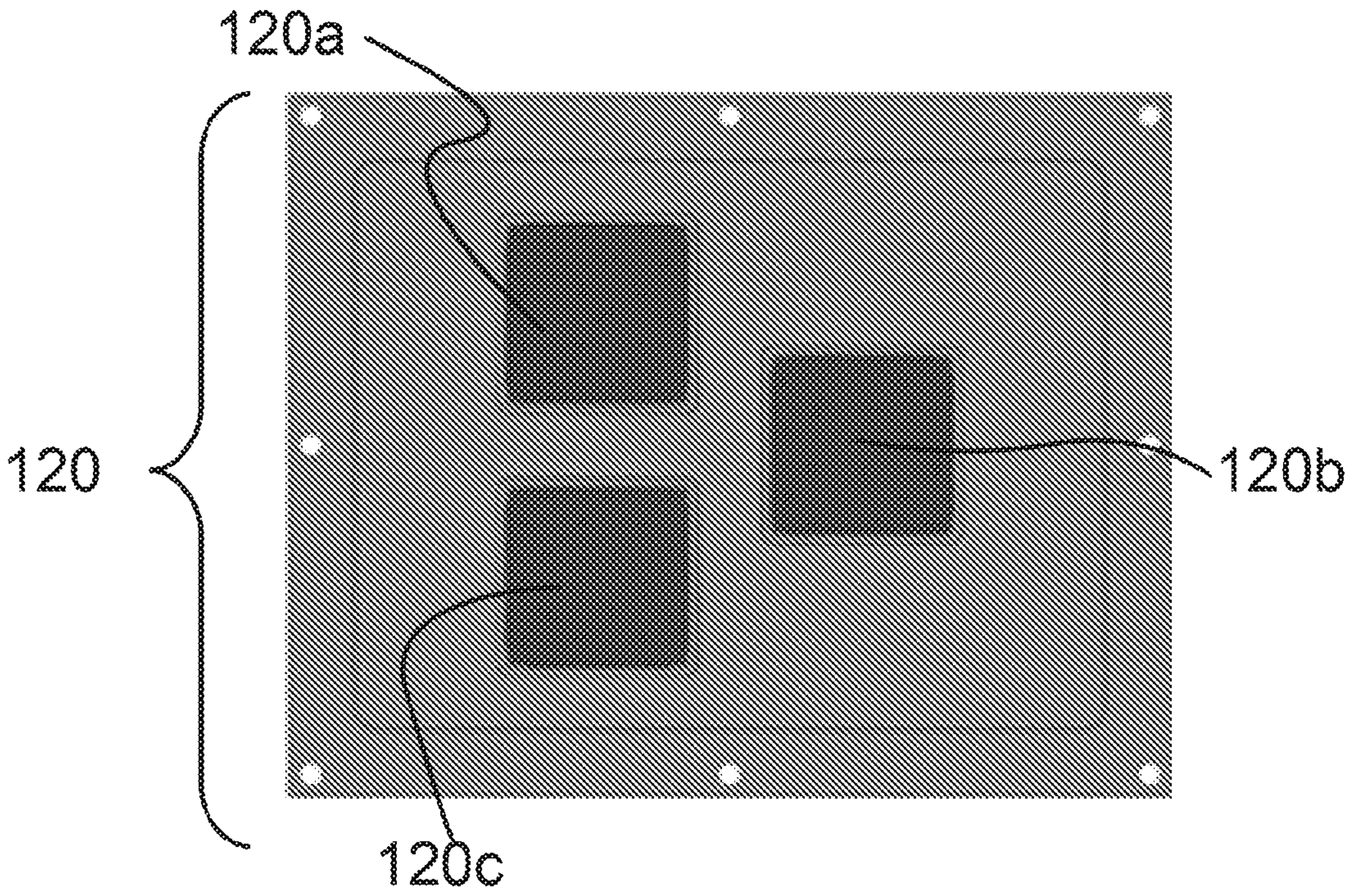


FIG. 15A

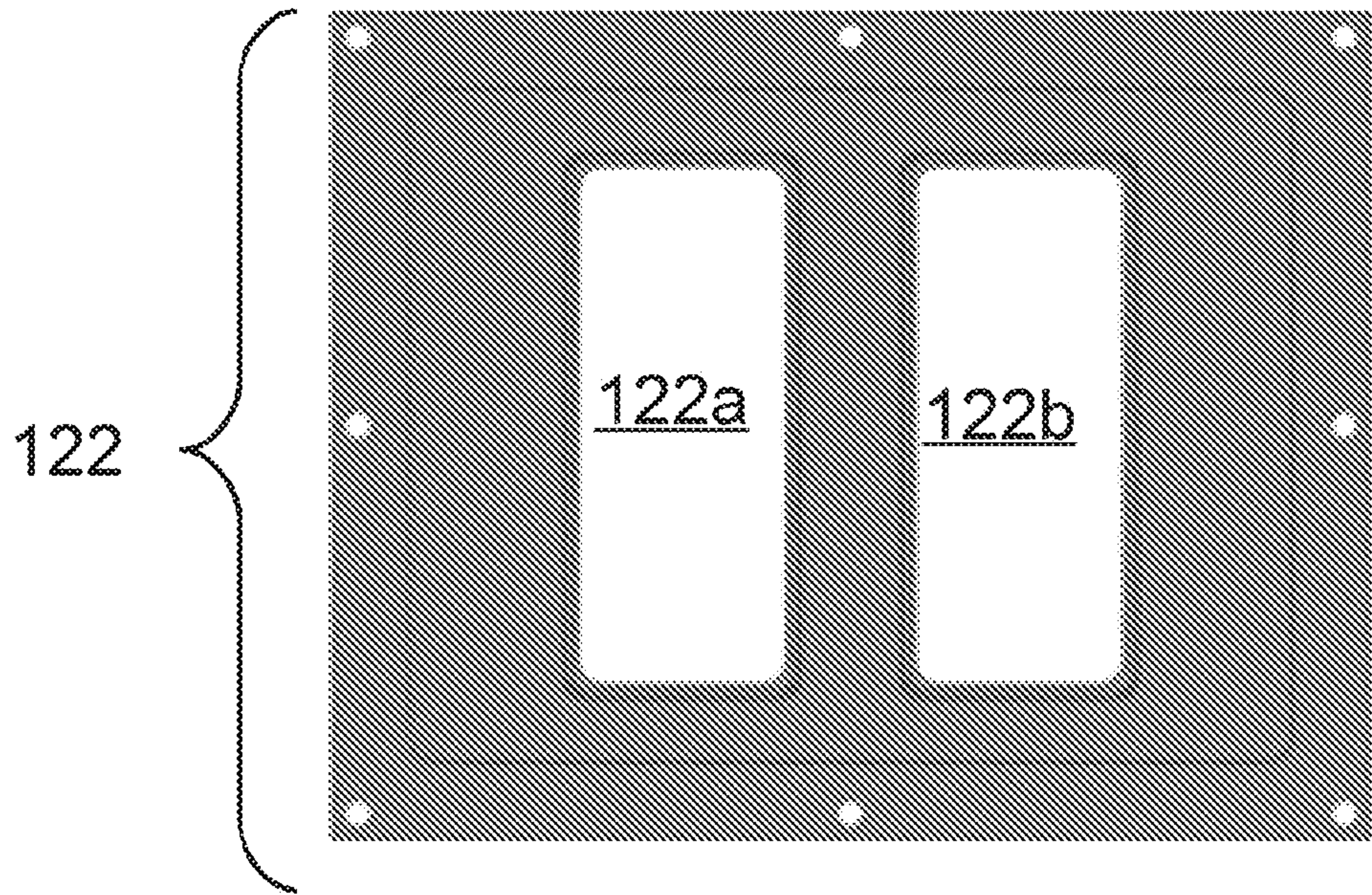


FIG. 15B

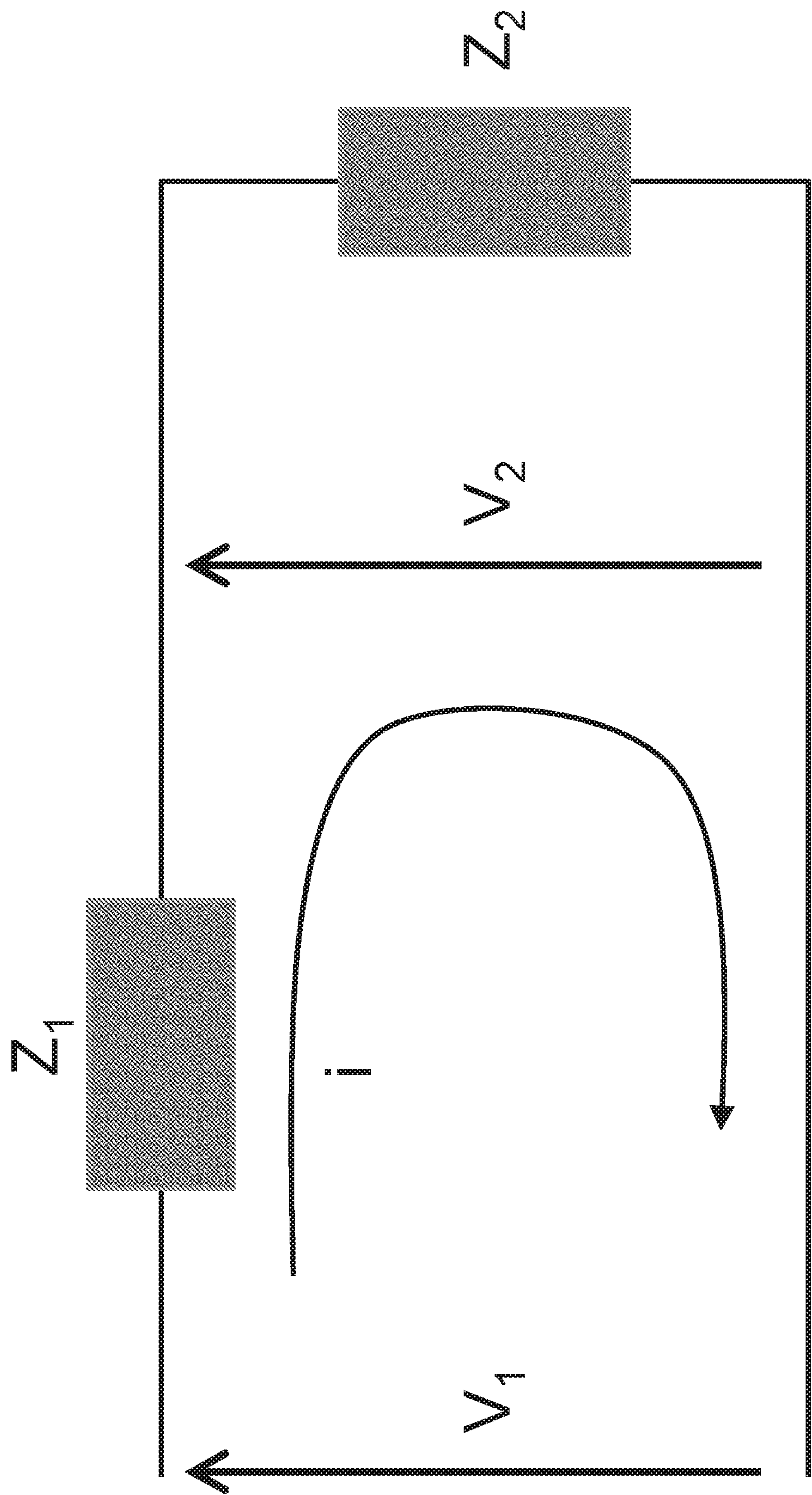


FIG. 16A

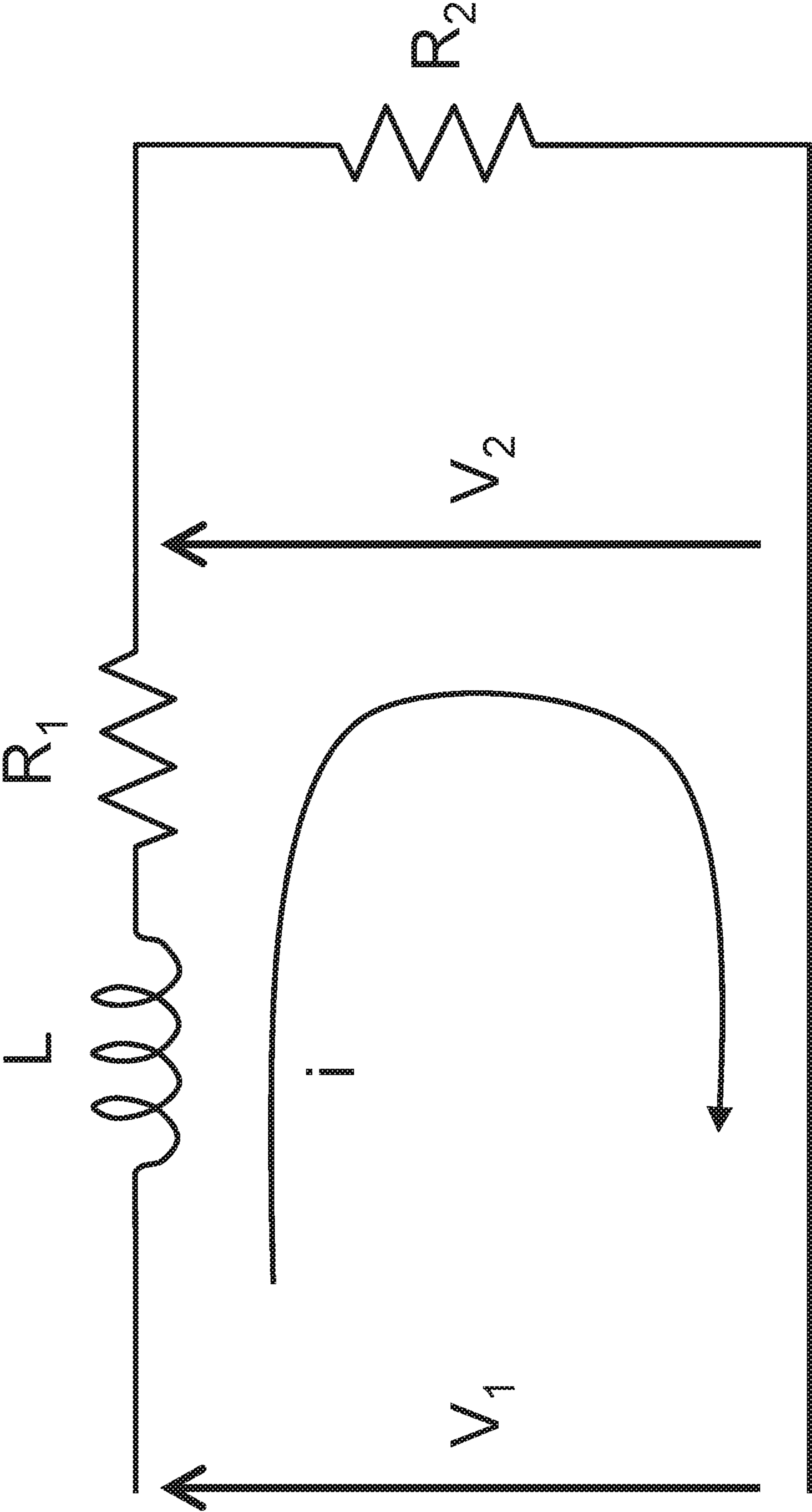


FIG. 16B

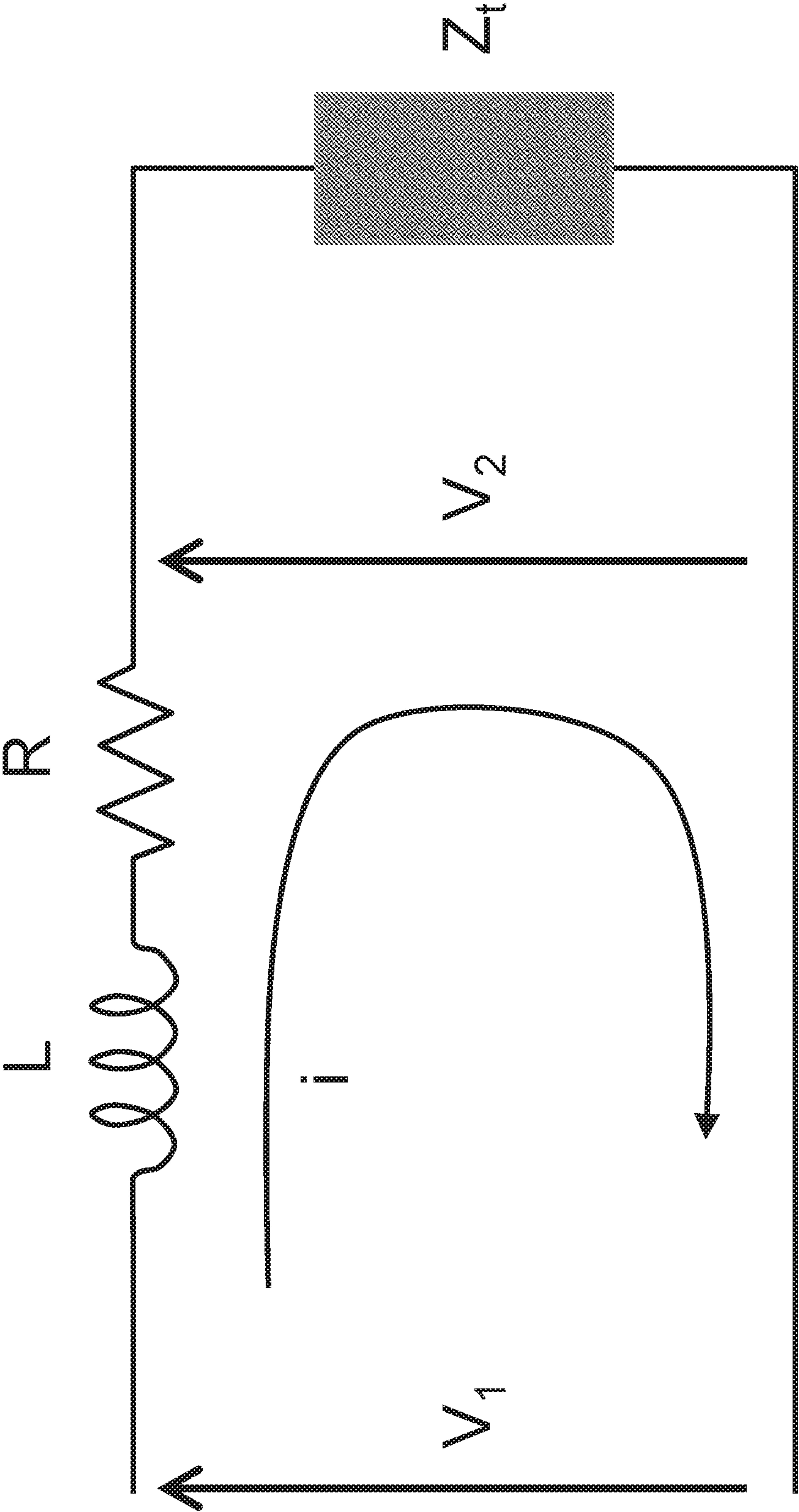


FIG. 16C

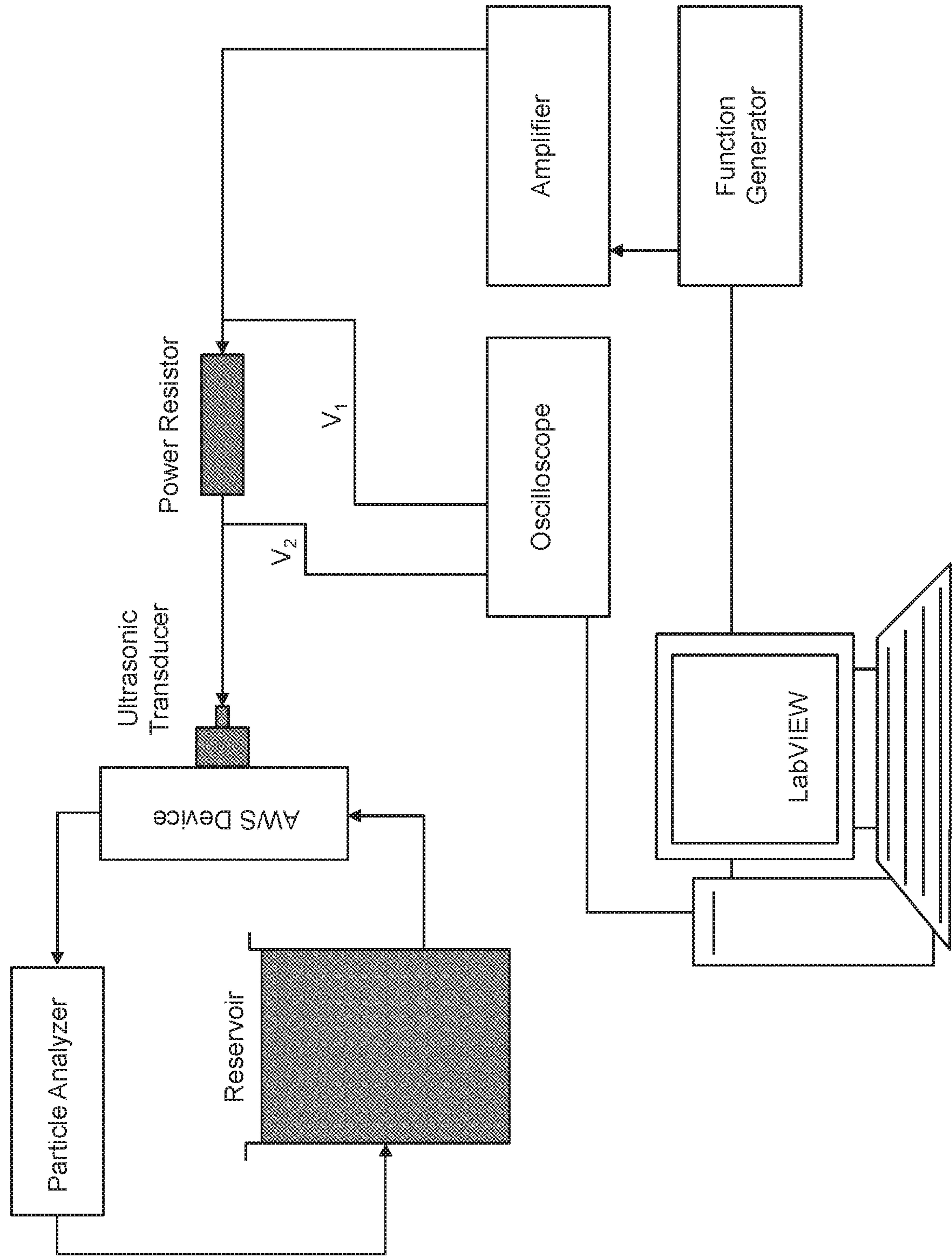


FIG. 16D

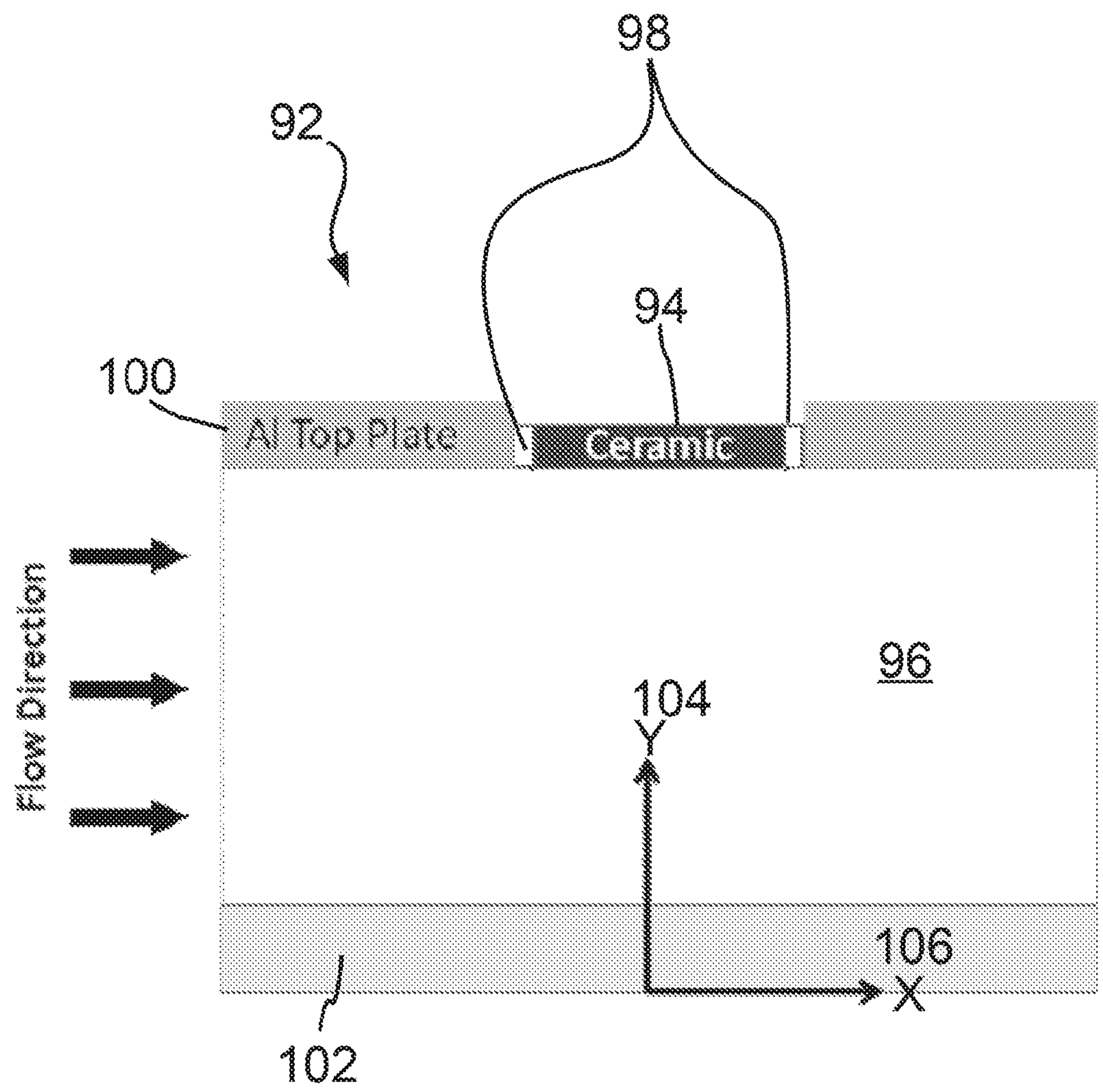


FIG. 17

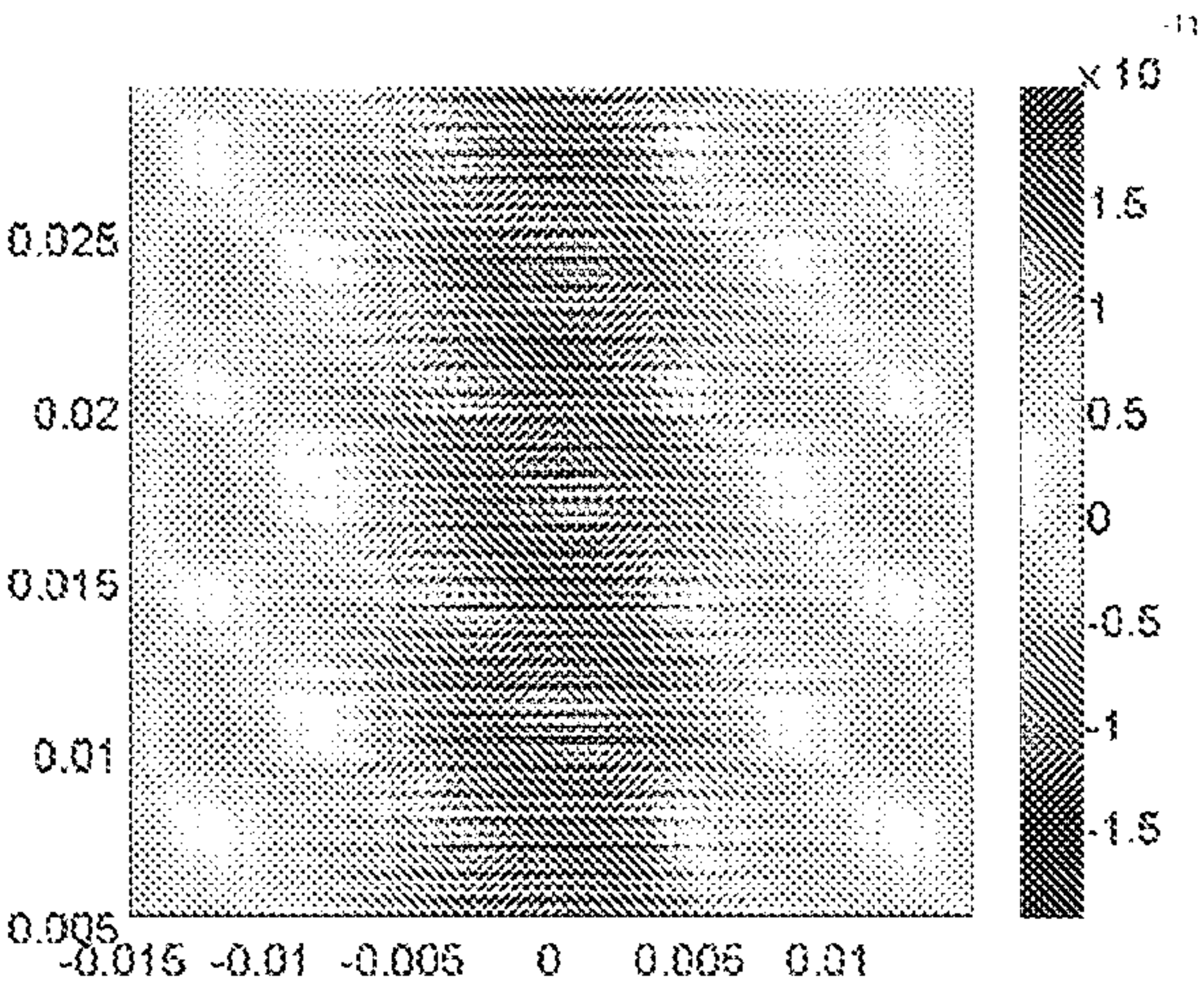


FIG. 18

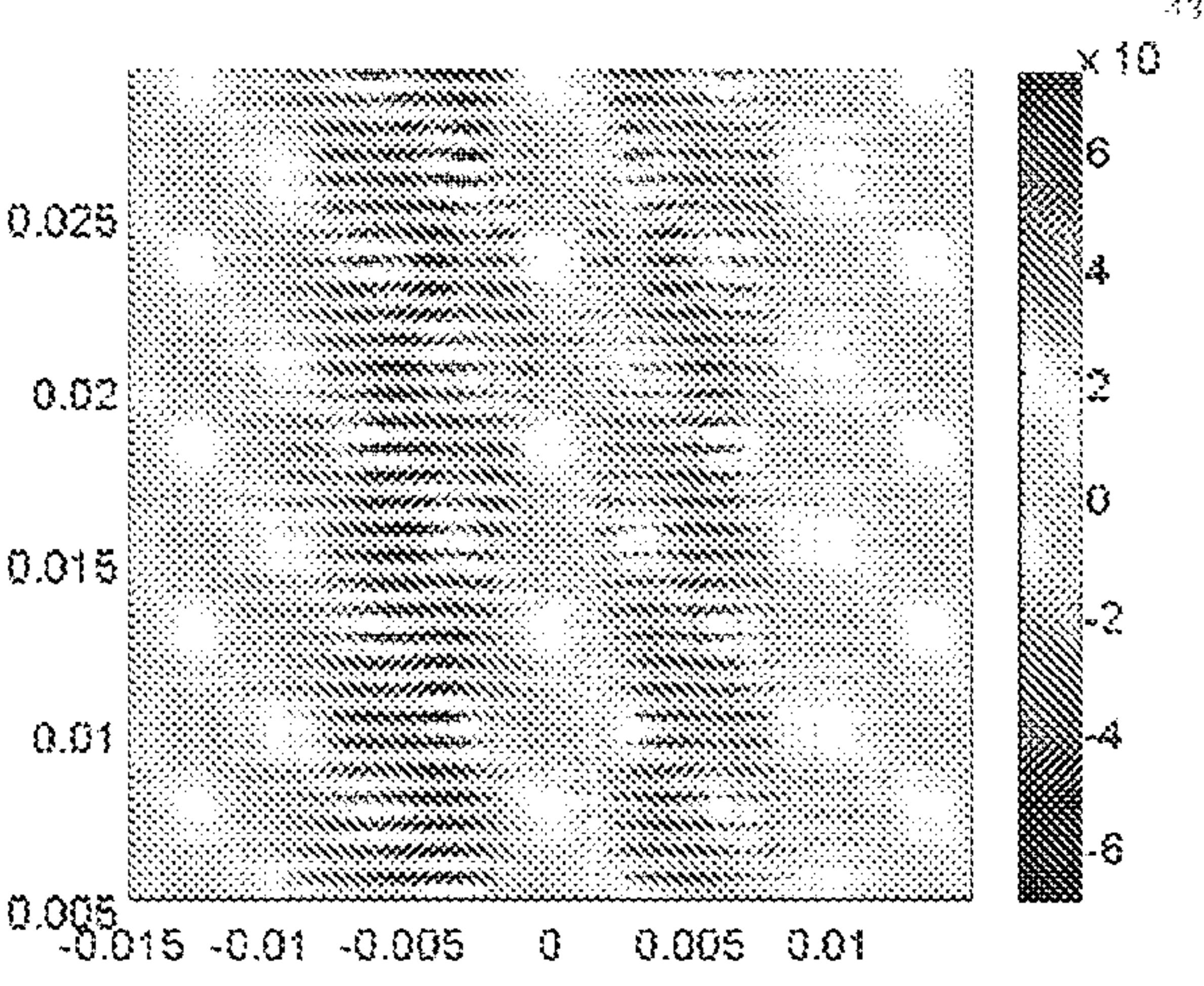


FIG. 19

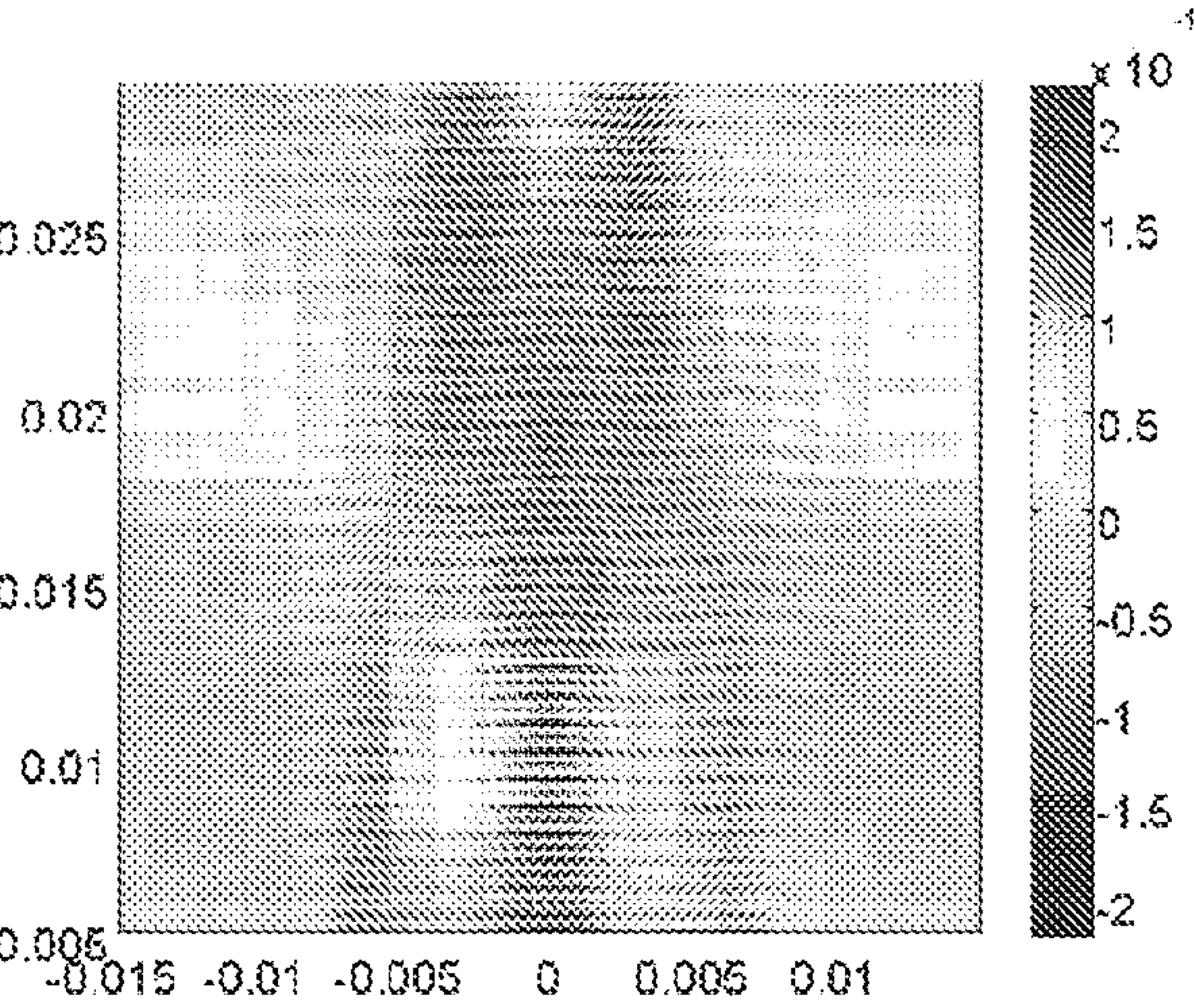


FIG. 20

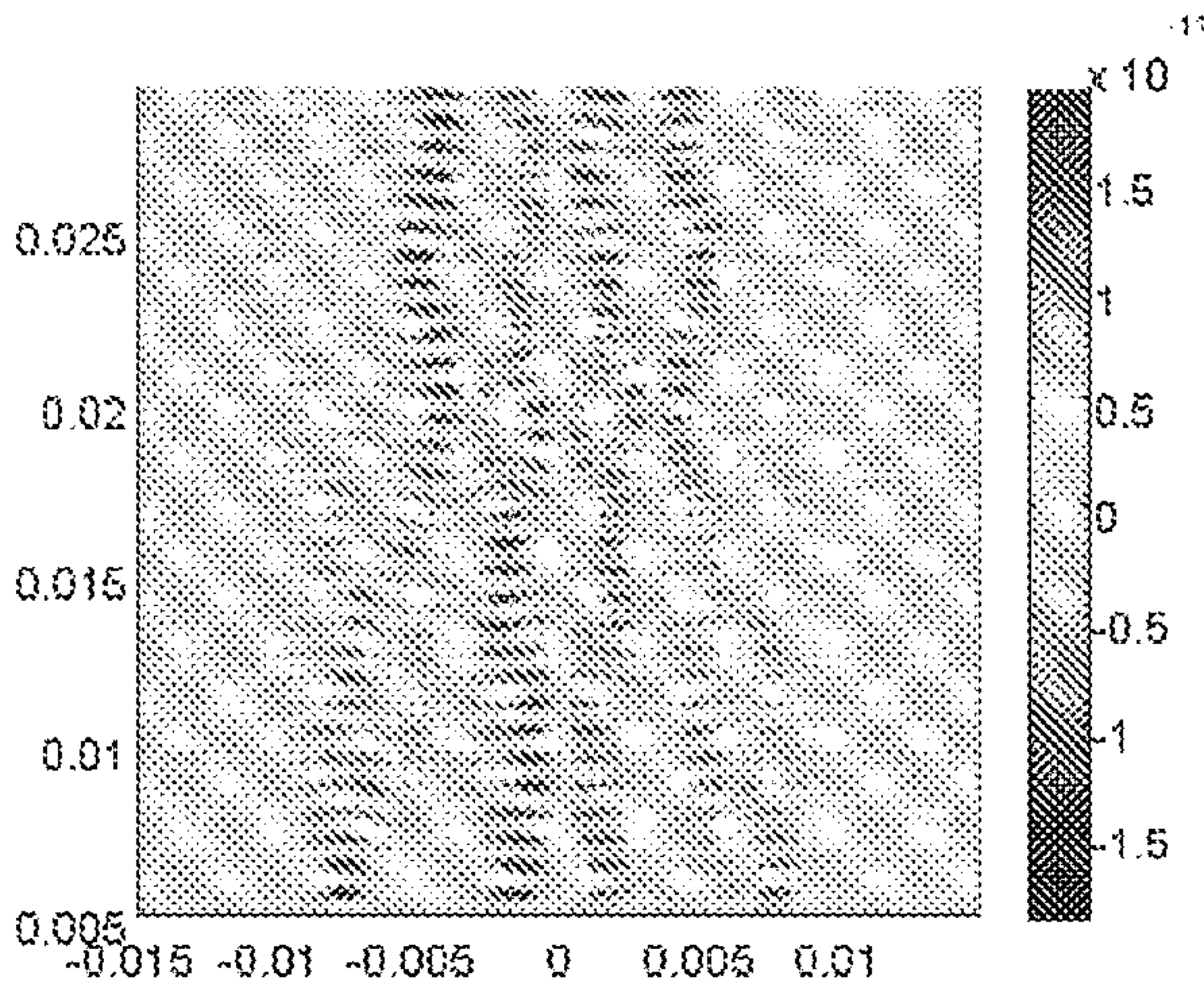


FIG. 21

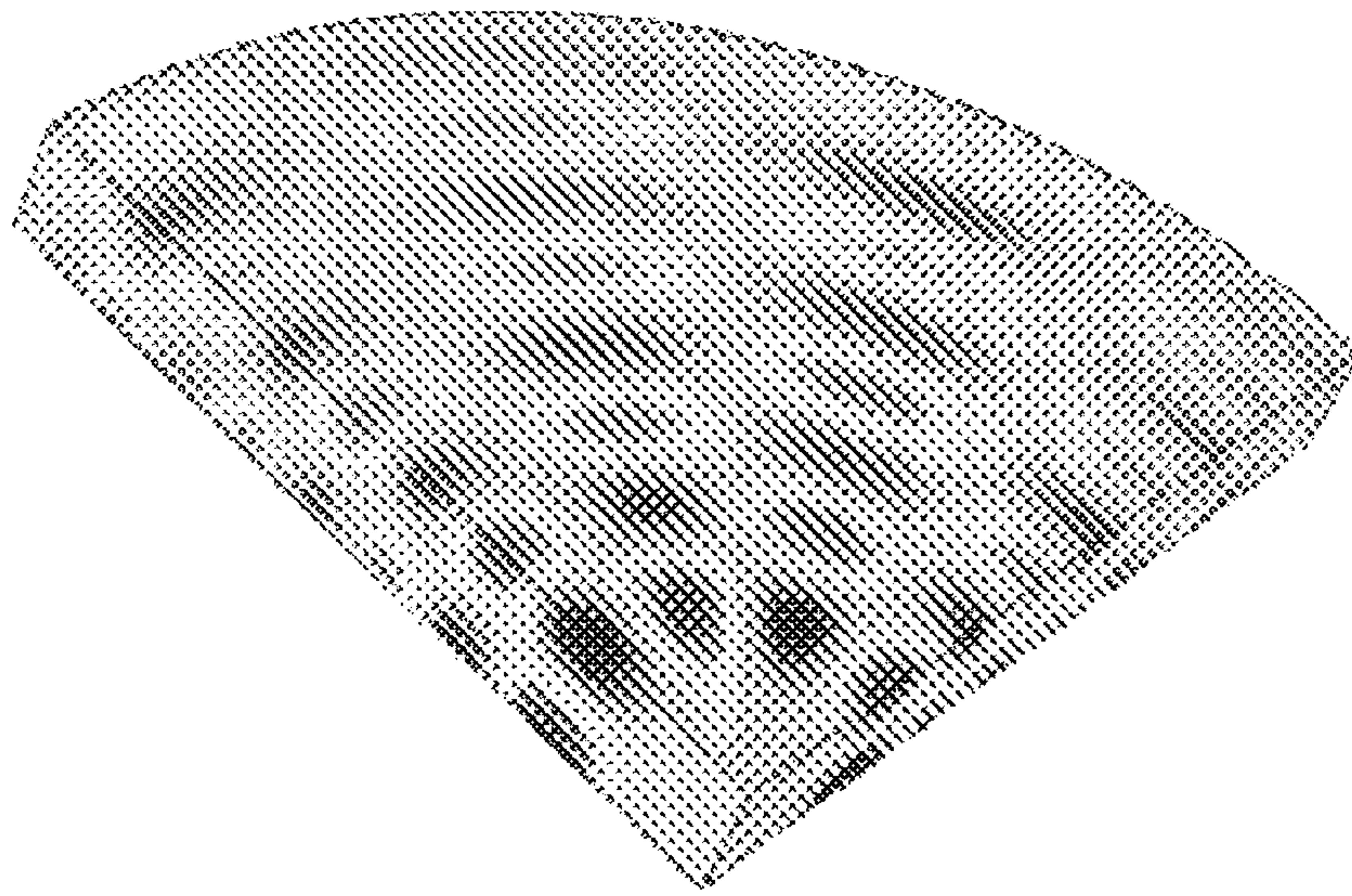


FIG. 22

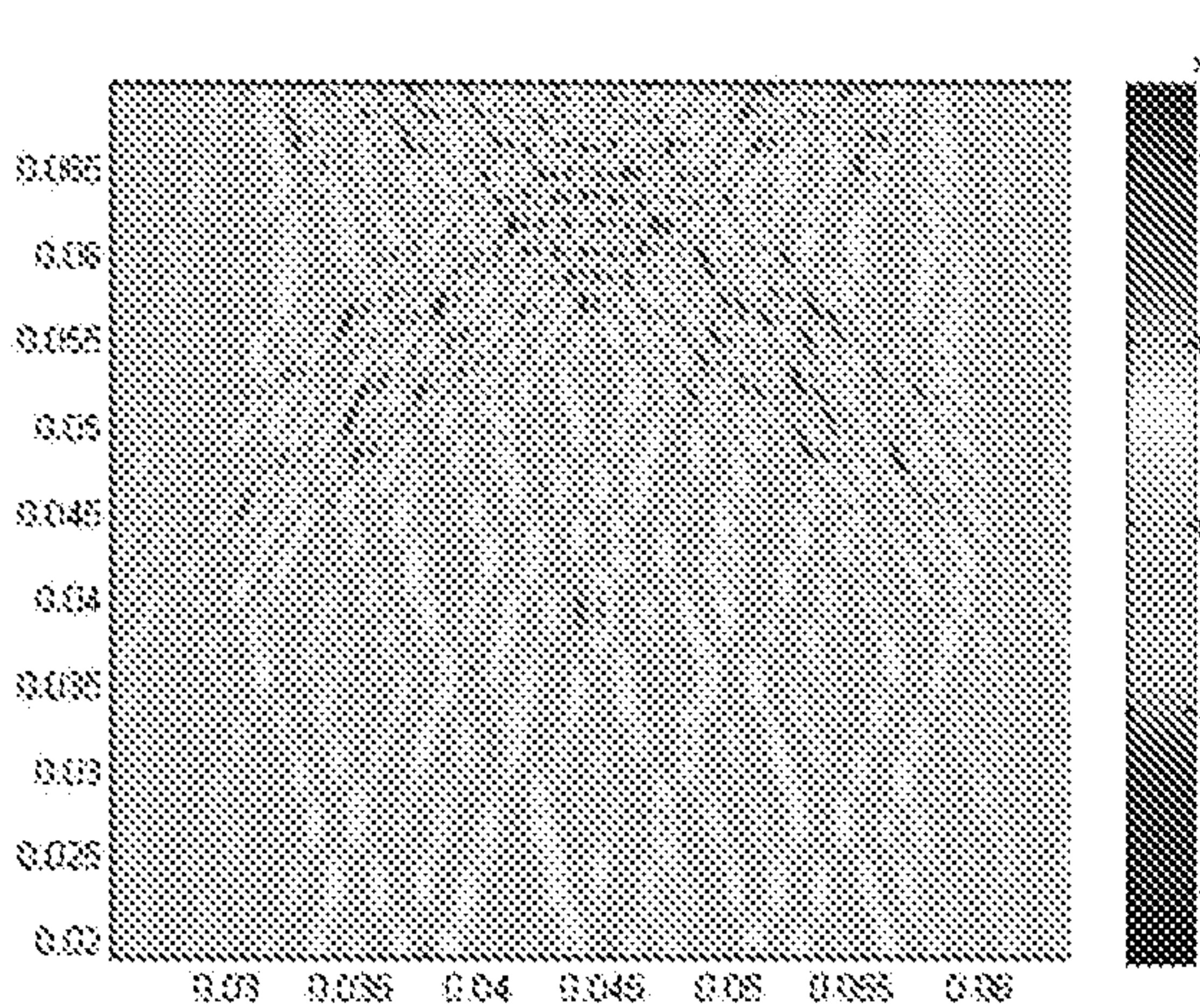


FIG. 23

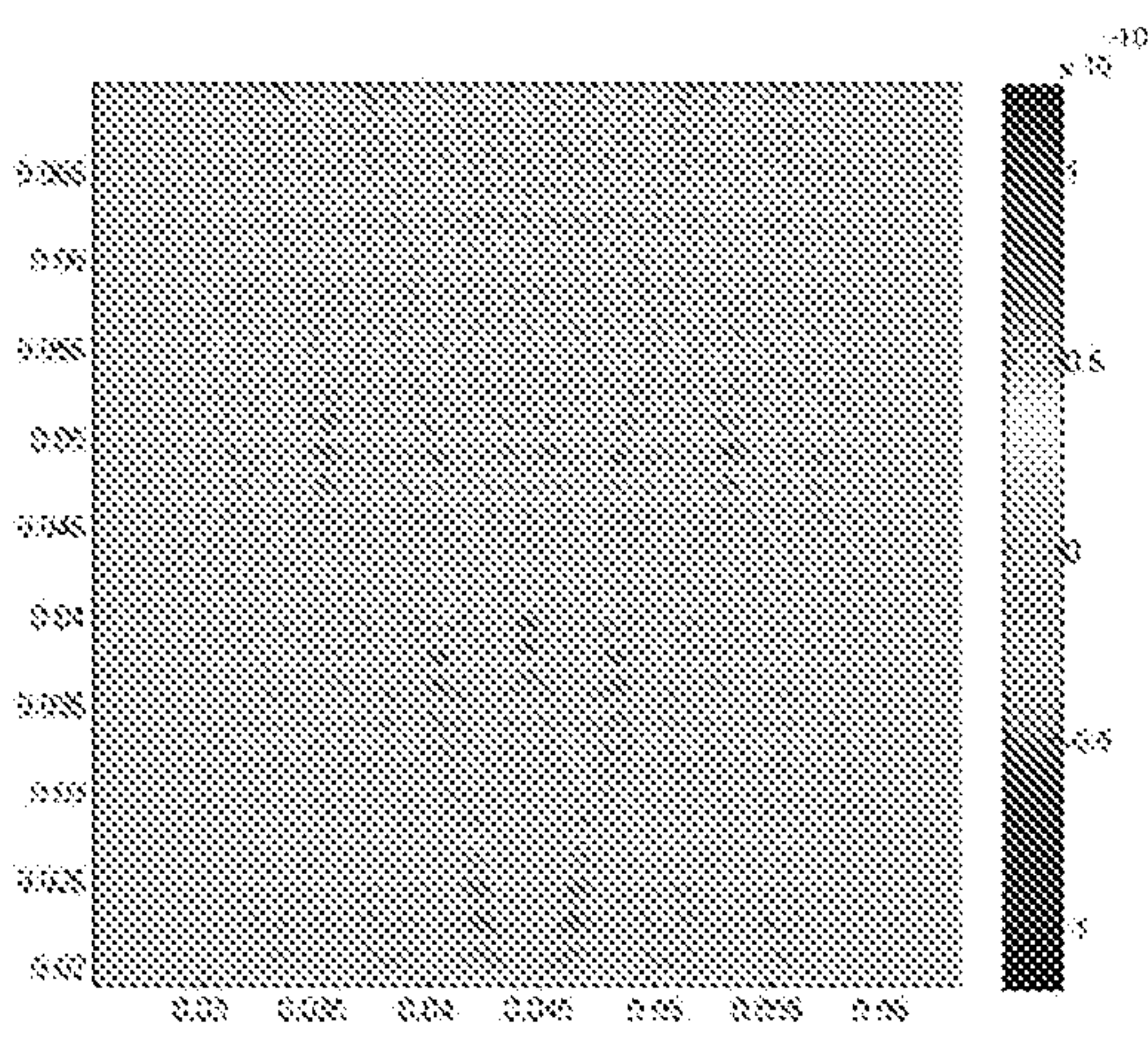


FIG. 24

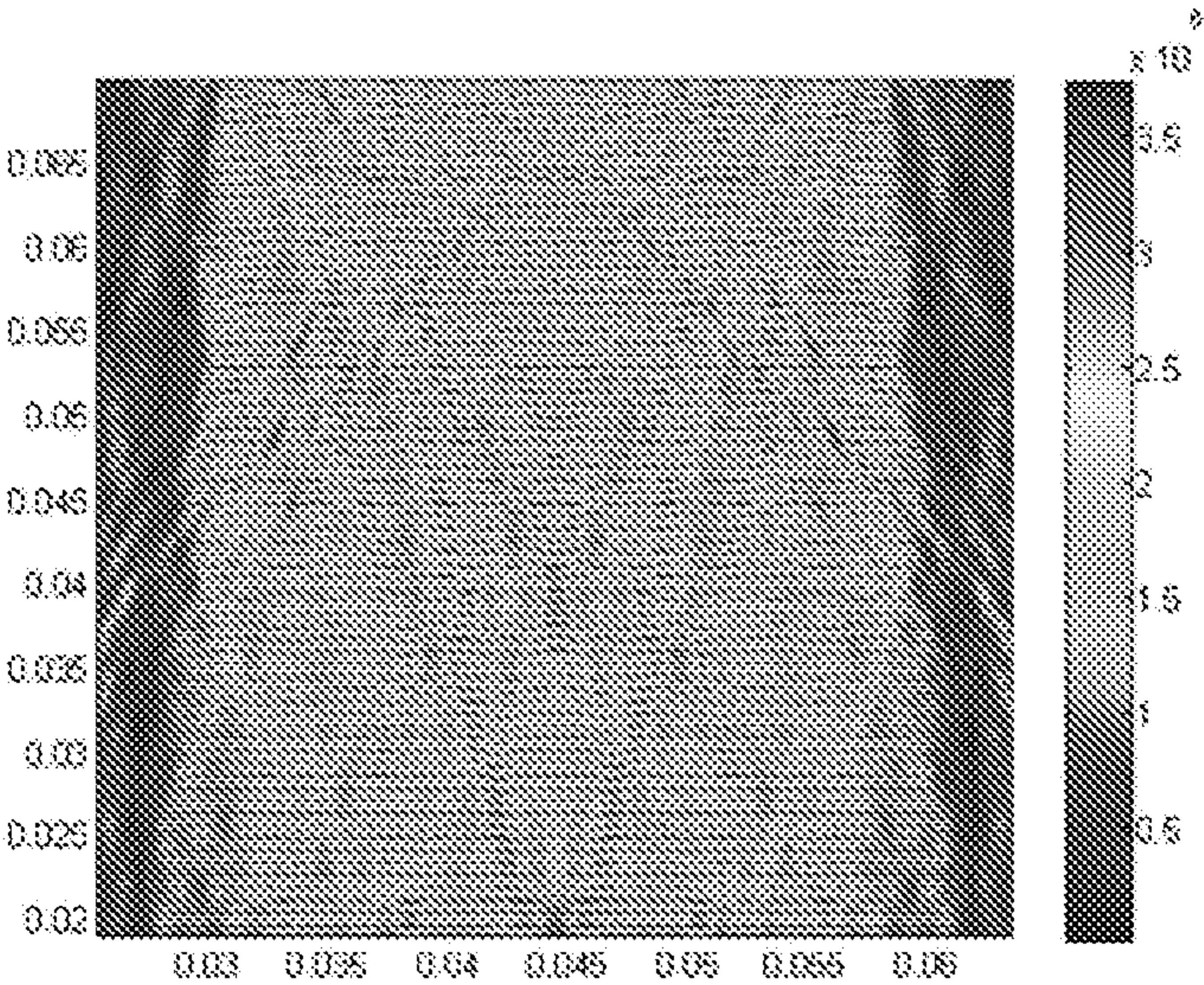


FIG. 25

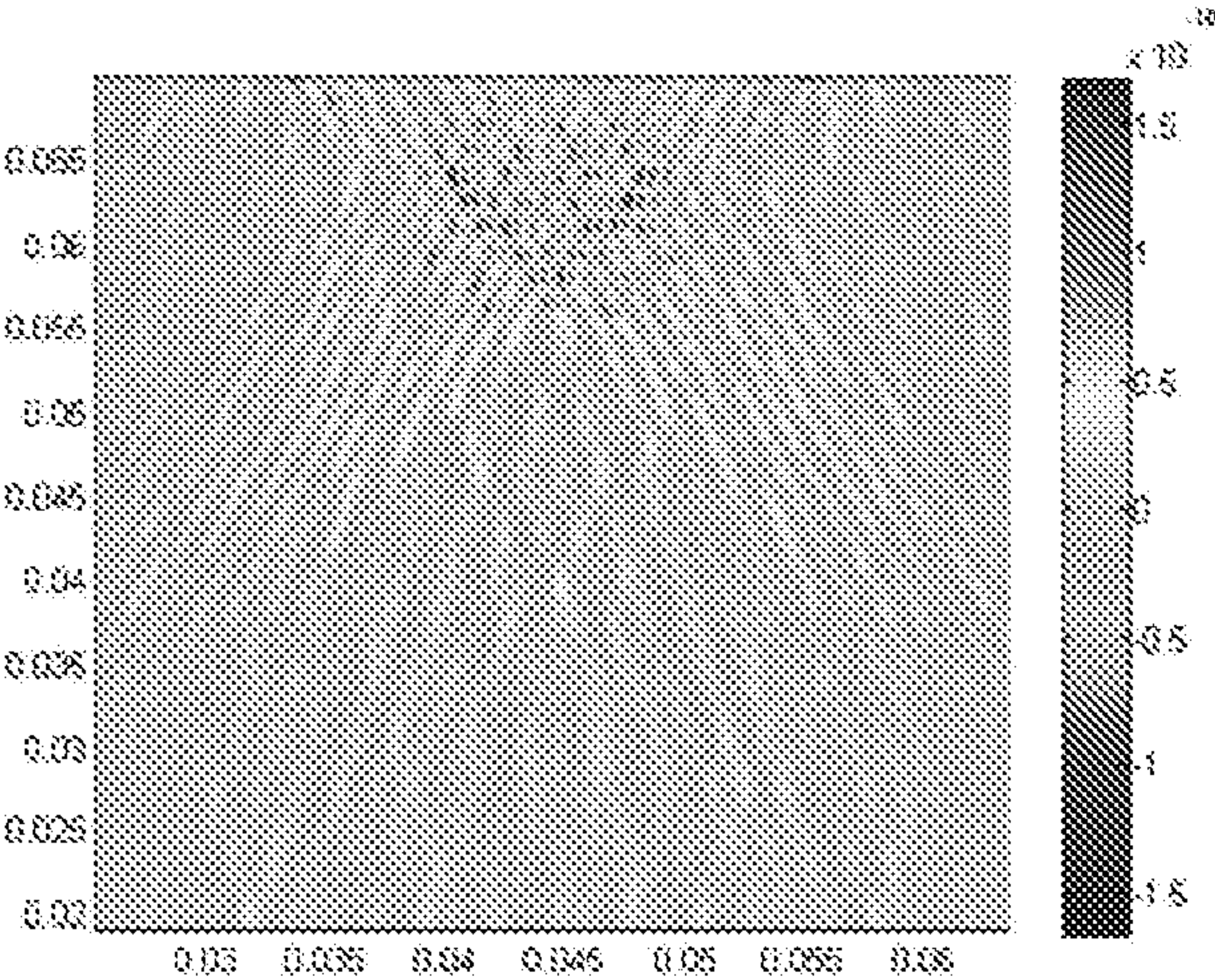


FIG. 26

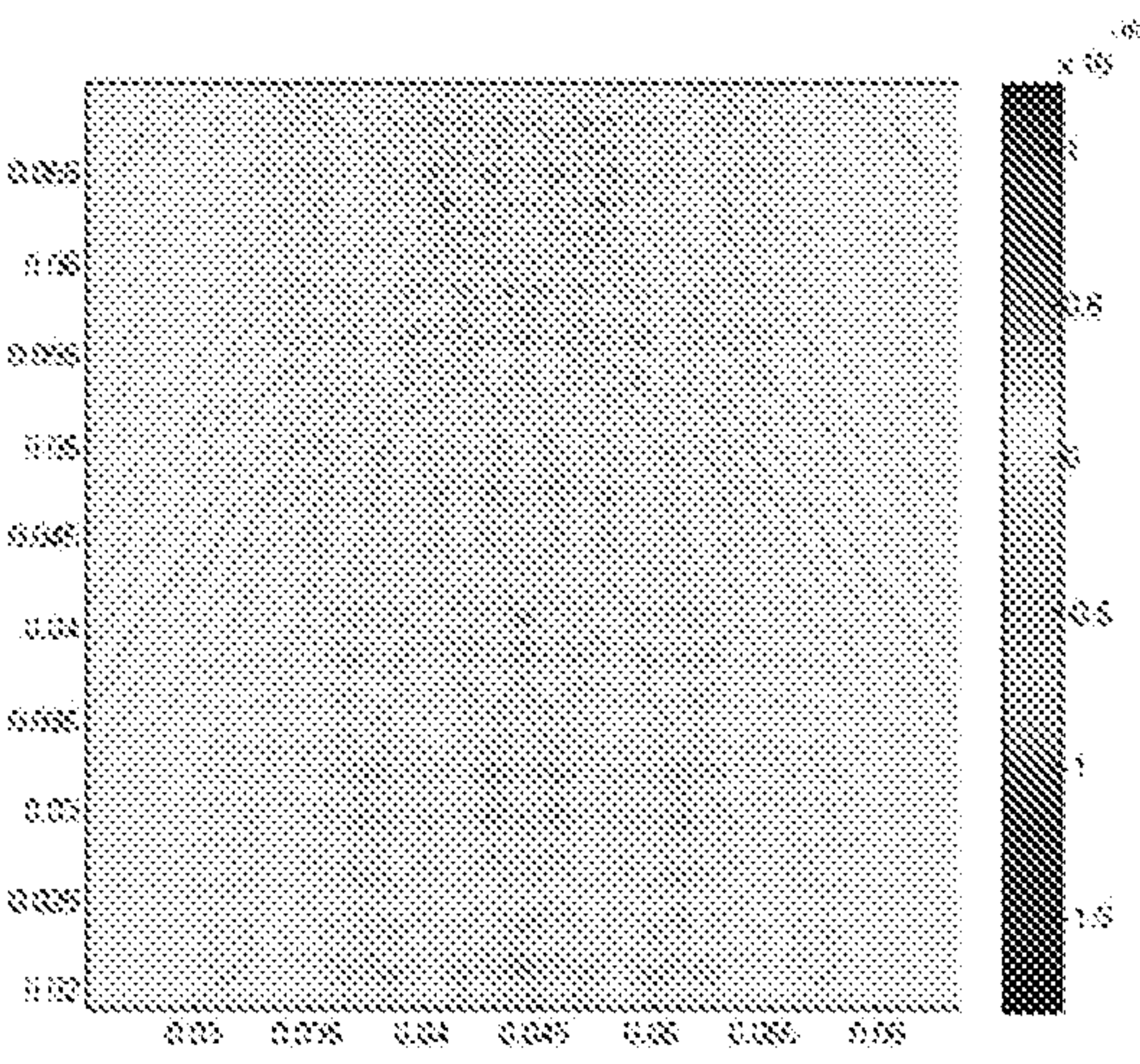


FIG. 27

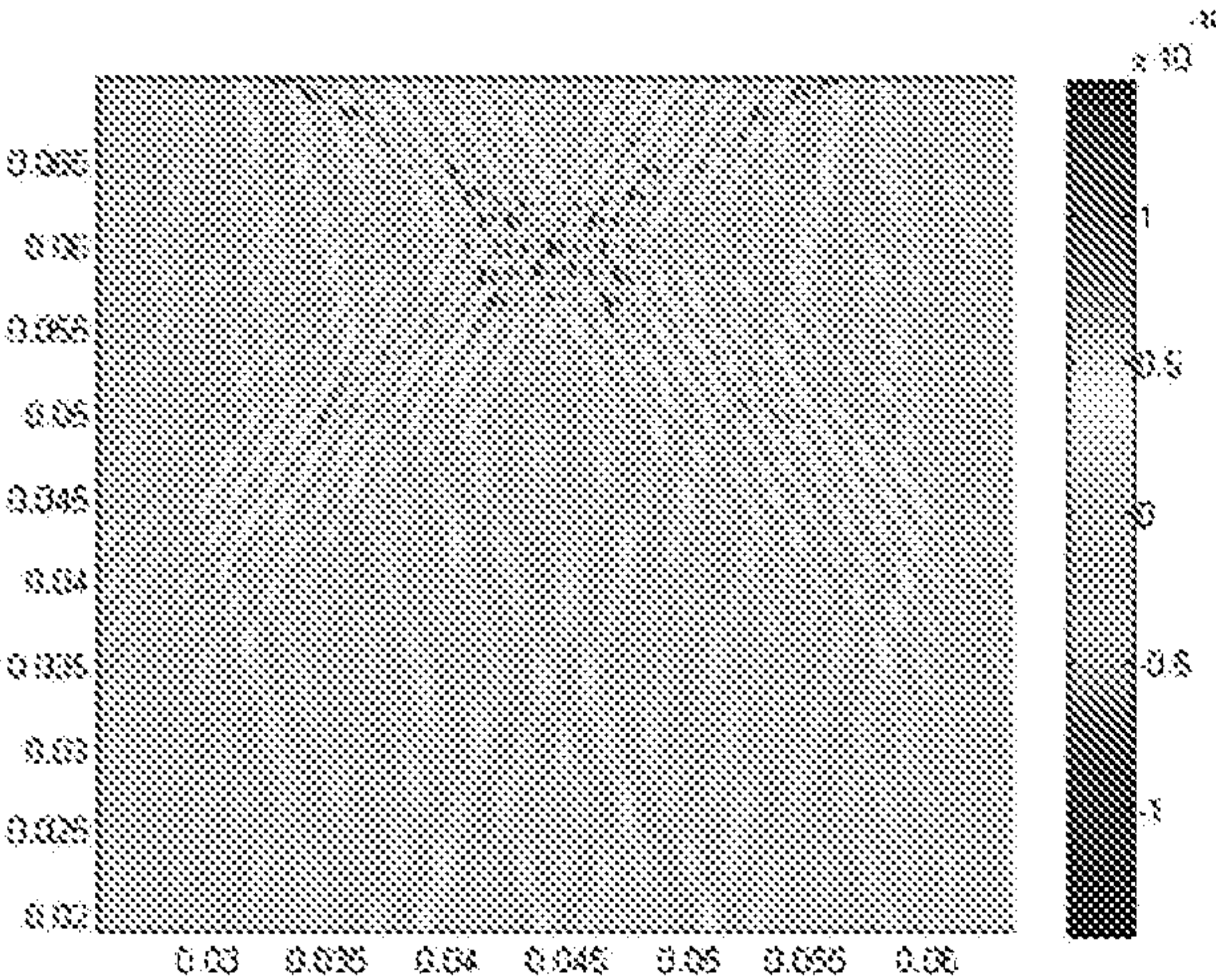


FIG. 28

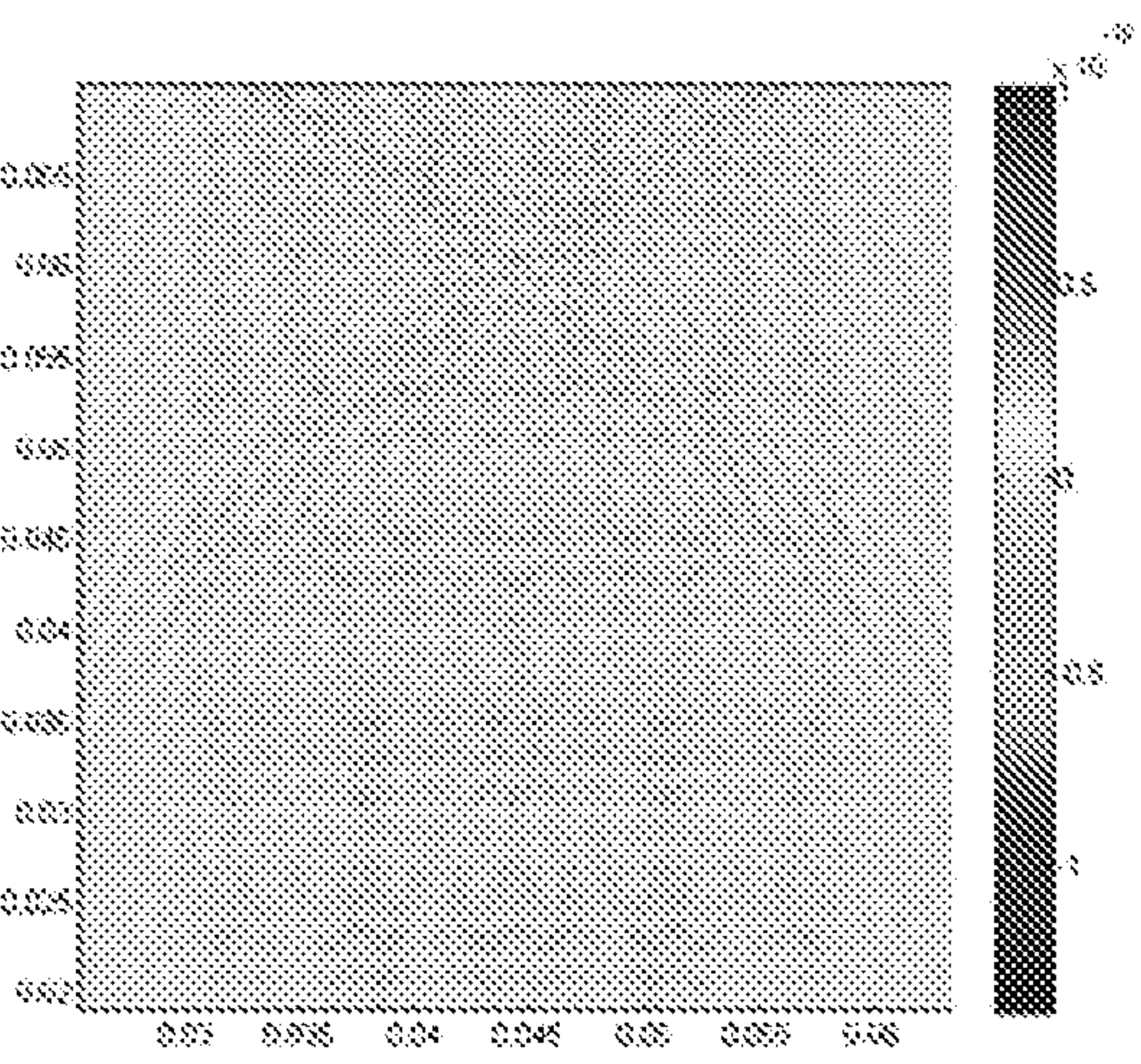


FIG. 29

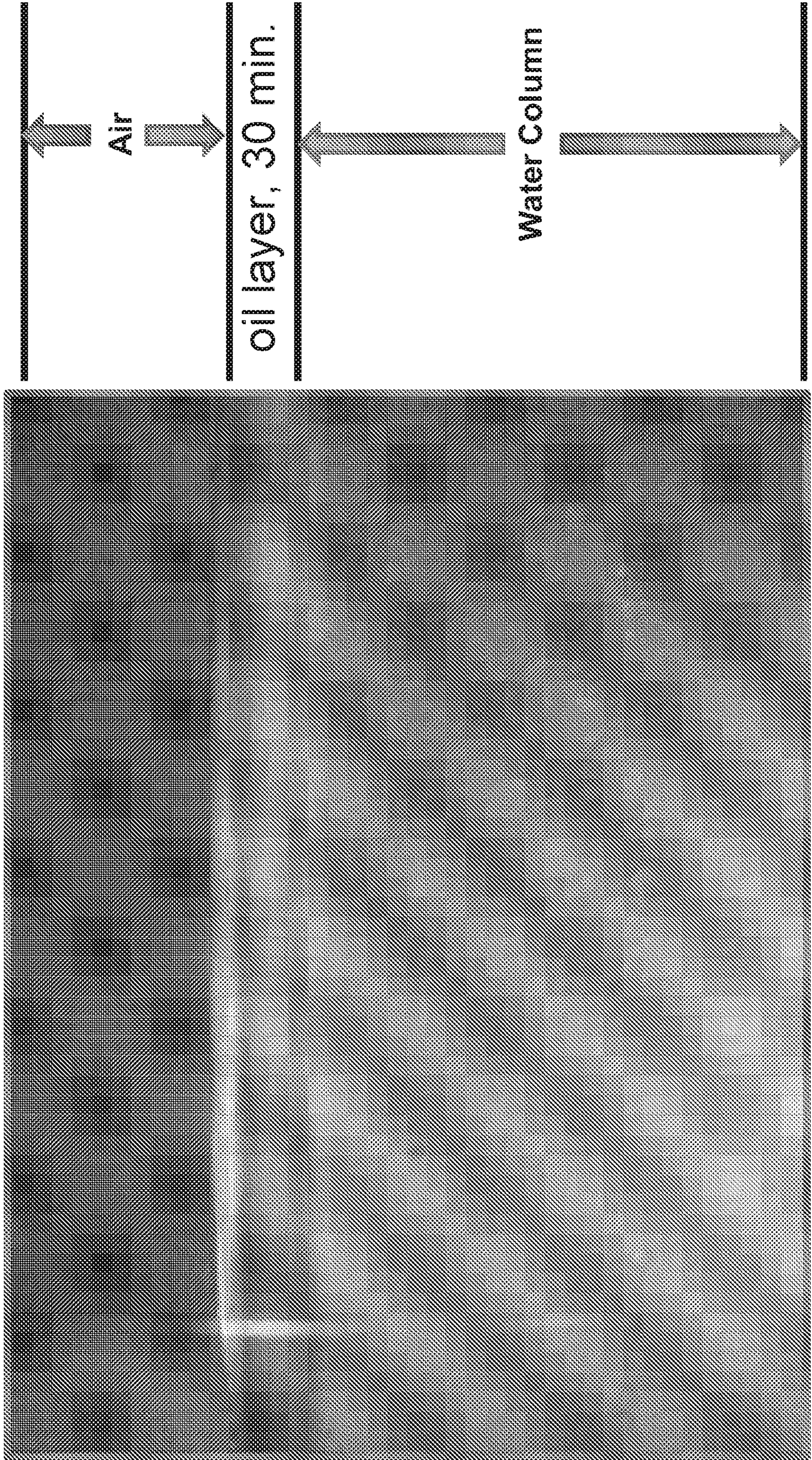


FIG. 30