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Plasma Physics Laboratory

Department of Physics

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APPARATUS FOR RECORDING OSCILLATION PROPERTIES OF A PENNING IONIZATION GAUGE AT VERY HIGH FREQUENCIES

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Approved: ______________________

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ABSTRACT

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In extending our previous experiments on VHF oscillations in a Penning Gauge, we have assembled equipment to record simultaneously the frequency spectrum of the oscillations, the discharge current, and the gas pressure. In use, we have held the magnetic field and anode voltage fixed and varied the anode voltage synchronously with the motion of the recording film (used for the oscillation spectra) and charts. The system, which may be of use in other experiments, is described and typical data recorded for the Penning Gauge are shown and discussed briefly.

Author

In extending our studies of the V.H.F. oscillations in the Penning ionization gauge, we have developed a system for simultaneously recording several of the parameters involved. As is typical of discharge phenomena, the properties of the gauge are only moderately stable and it thus becomes necessary to abandon point by point procedures in favor of automatic recording.

The system which we have designed is of use in the study of phenomena in which an accurate, permanent record of the V.H.F. spectrum as a function of some variable is desired.

Figure 1 shows the basic system. The dependent parameters which are reducible to a voltage are recorded on standard strip chart recorders. In case the independent parameter is not linear in time, a marker generator for the independent variable is provided. Markers are fed to the recorders through isolation circuits. The R.F. signal from the discharge is fed to the spectrum analyzer. The horizontal output of the analyzer is used to sweep an oscilloscope vertically. The vertical signal from the spectrum analyzer is amplified and markers are superimposed on the signal. This is then used to intensity modulate the oscilloscope trace. The display is thus a vertical line with points whose position and width correspond to the frequency and width of the oscillations. The intensity of the spot is proportional to the amplitude of the signal. If the oscilloscope is now viewed by a moving film (synchronous with a change of the independent variable) a record of the frequency, width, and amplitude of the oscillations is obtained.

Our experiments have been on a Penning gauge which consists of two circular, aluminum cathodes at the ends of a right circular conducting cylinder; these are operated at ground potential. A

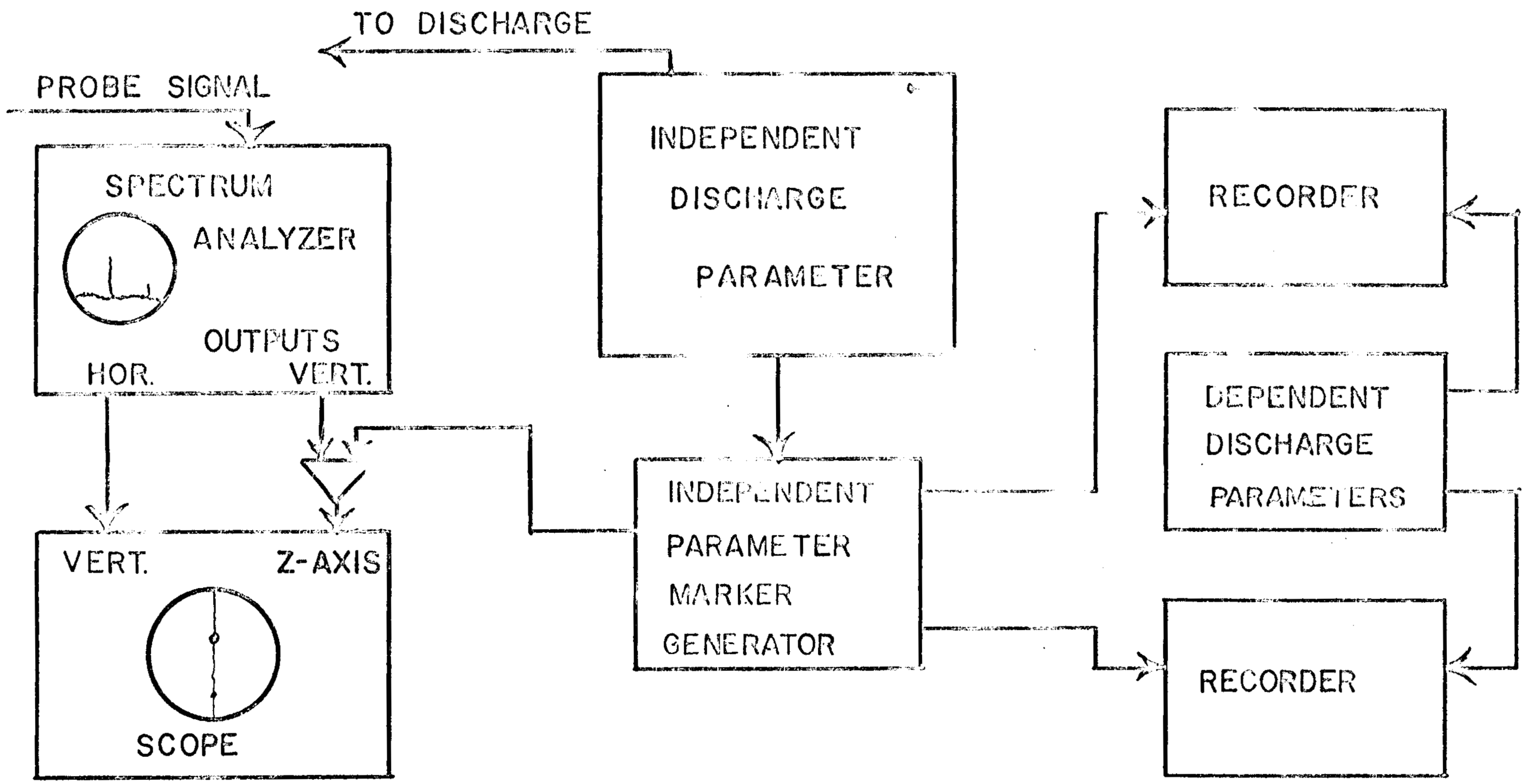

Fig. 1 Block Diagram of General Experimental Arrangement

The scope is viewed by a moving film camera.

positive high voltage is applied to a circular wire anode which is located symmetrically in the center of the cylinder. The system is operated at pressures of the order of one micron of mercury and with an axial magnetic induction of the order of 200 gauss.

Our prime concern in the development of the system was to obtain volt-ampere and oscillation characteristics of the discharge in regions at which oscillations occurred. We also needed a record of the pressure because many of the observed effects could be attributed to pressure variations and we wished to disregard these.

The experimental arrangement is shown in Figure 2. The anode is coupled to the power supply through a R.F. choke; a series resistor is used to measure the current which is recorded on a strip-chart recorder. The pressure signal from an Alphatron gauge is recorded on an identical recorder. The power supply can be swept through 500 volts by varying an external resistance. Voltage markers are produced by a series of Schmitt trigger circuits and impressed on the two recorders. The spectrum analyzer is coupled to the anode through a capacitor. It is connected to an oscilloscope in the manner described above. The voltage markers are referenced in time to the retrace of the oscilloscope and thus appear at a specific position on the next trace. This was necessary in order to avoid confusion with the spectrum. The error it introduces is less than the accuracy of the recorders. A precision potentiometer is coupled to the camera drive and is used to sweep the power supply in a triangular waveform.

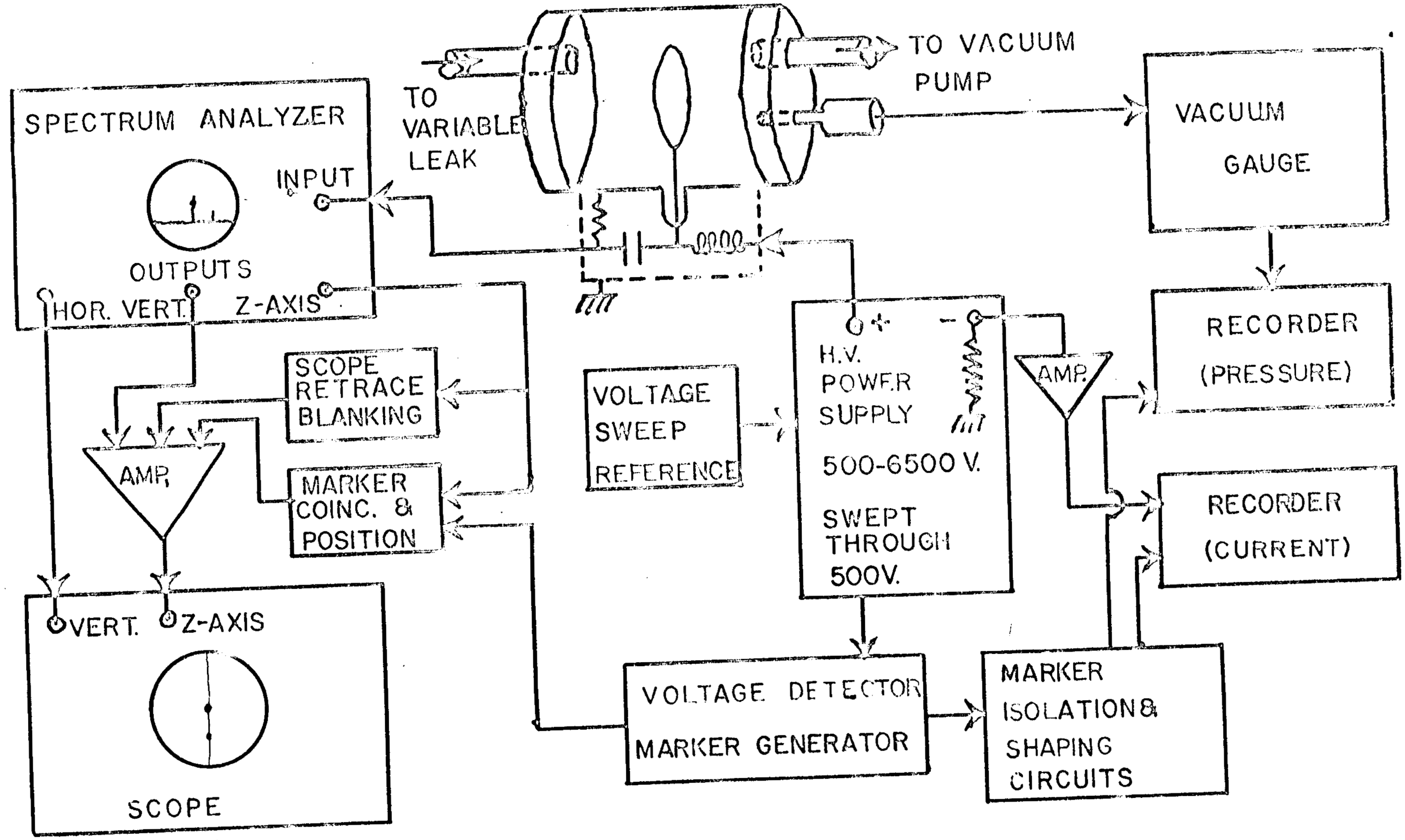

Fig. 2 Block Diagram of Experimental Apparatus for Recording Parameters of Penning Gauge The scope is viewed by a moving film camera. The voltage sweep reference is a precision potentiometer which is driven by the camera.

Figure 3 shows a series of spectra which were obtained with this system. The two bottom traces were made under identical conditions and show two different portions of the spectrum. The sweep width of each is 20 megacycles/second and the center frequencies are:

bottom trace--- 350 megacycles/second

second trace--- 520 megacycles/second
180

On the spectrum analyzer which we used, the two lowest ranges overlap and thus the two signals are on separate bands. Frequency increases from the bottom of all traces and voltage varies from right to left. The voltage on the bottom two traces is 2700 - 2900 - 2700. The top four spectra were similarly different regions of the spectrum with all other parameters constant. From top to bottom the center frequencies are 360, 240, 560, (370 or 105) megacycles/second. The sweep width was 70 megacycles/second and the voltage varied from right to left 1800 - 2300 - 1800.

Figure 4 shows the current, pressure, and spectrum for another set of discharge parameters. The pressure and current traces were made at the same time as the lower spectrum and are essentially the same as the ones which correspond to the upper film.

One purpose of these investigations was to verify the assumption that the oscillations could be interpreted as a coupling of the longitudinal electron oscillations with the plasmaguide modes of the cavity. That is, we wished to investigate the effects produced as one oscillation frequency was swept through the other. Although sweeping the voltage affects the discharge modes through the electron density, its principal effect is on the longitudinal electron oscillations. These interactions should manifest themselves as frequency "pulling" or mode jumps. Figure 5, which is

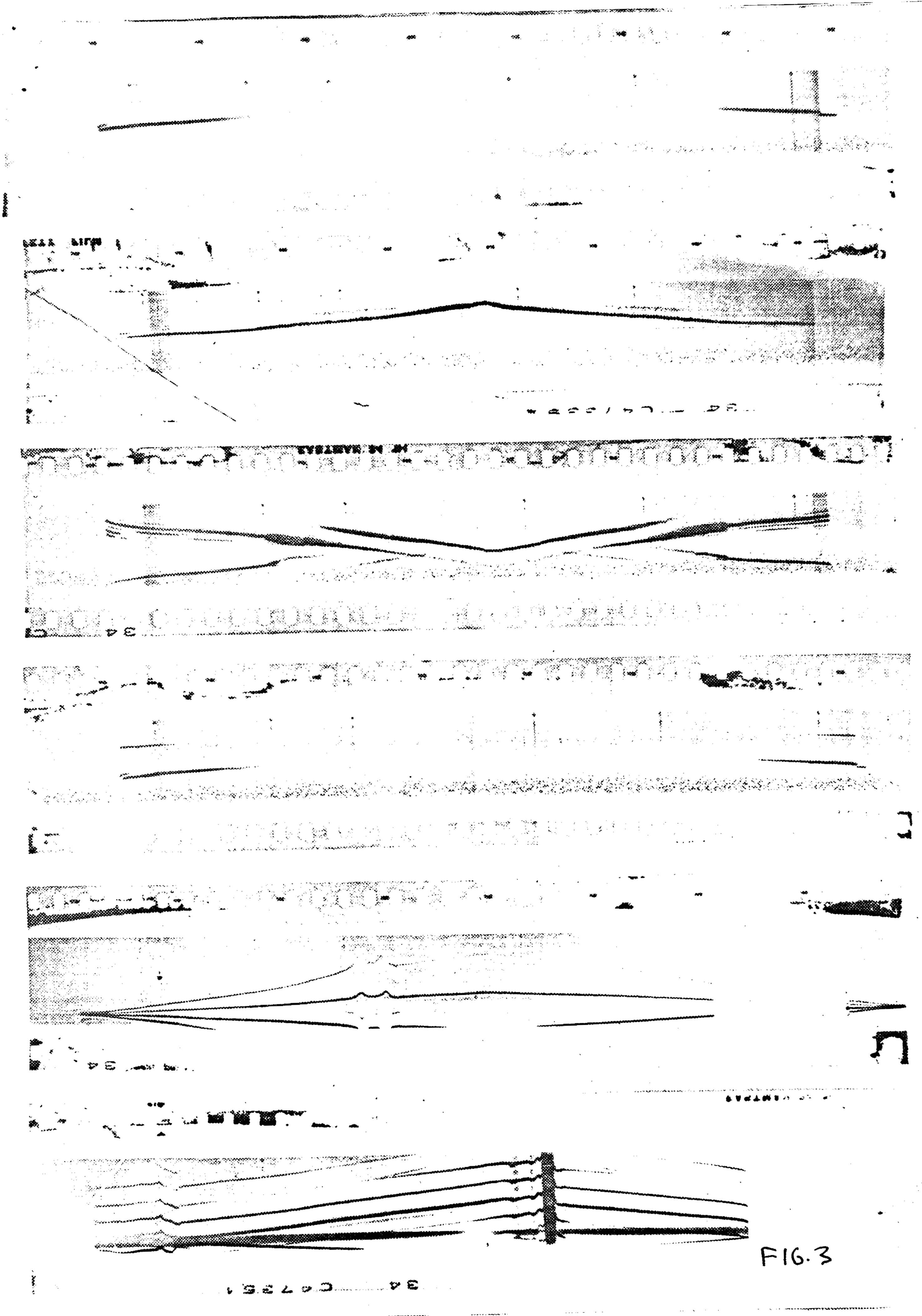

FIG. 3

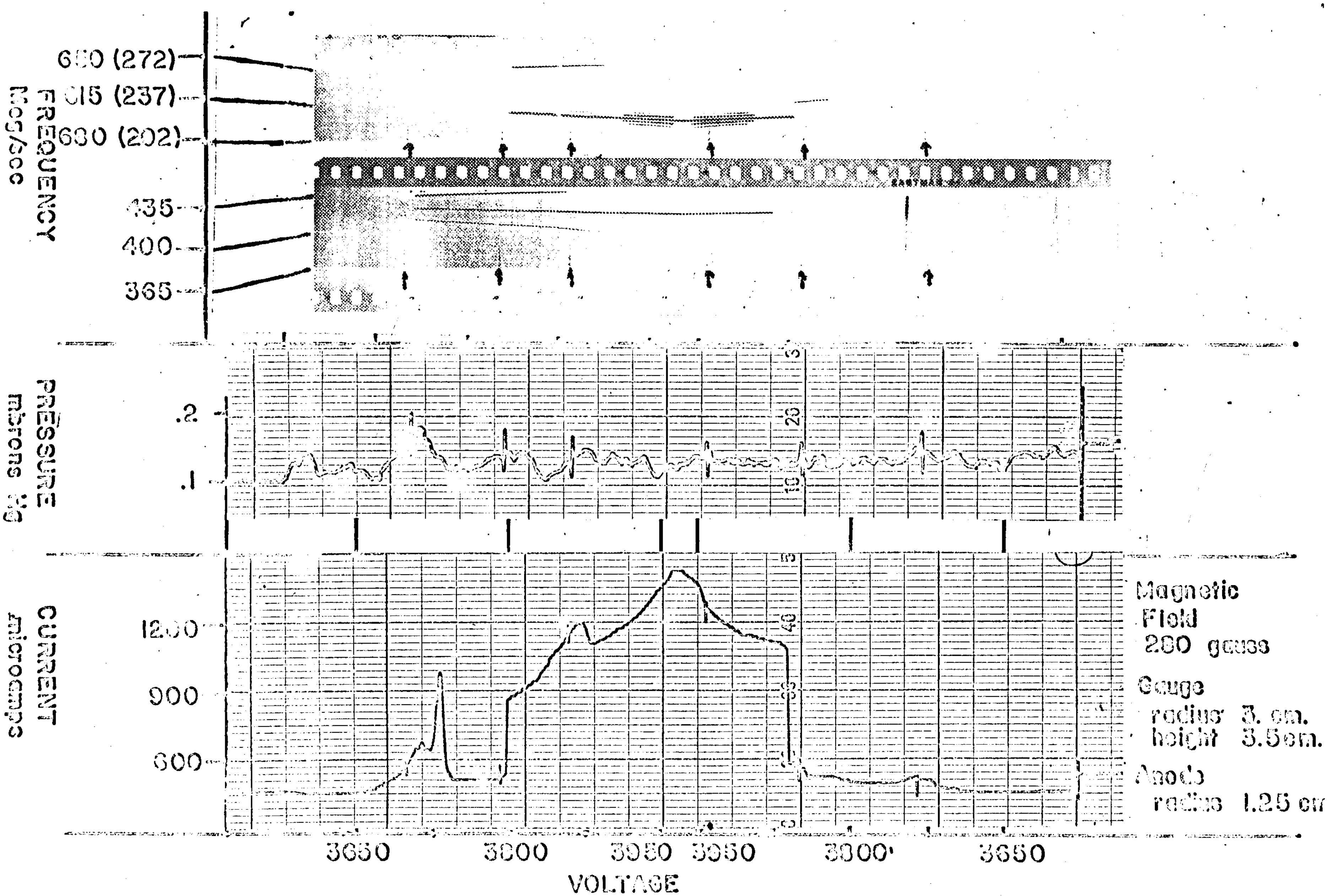

Fig. 4 Penning Gauge Data

a reproduction of the uppermost film in Figure 3, shows both the increasing and decreasing voltage versus frequency curves superimposed. The two frequency jumps qualitatively agree with the behavior expected from coupled oscillators. Figure 6 is a similar plot of one of the oscillations of Figure 4. The effect is usually more proncunced when the voltage is increasing. Not all of the oscillations exhibit this characteristic, but it is quite reproducible on those that do. This effect has yet to be studied in great detail so the results are very qualitative.

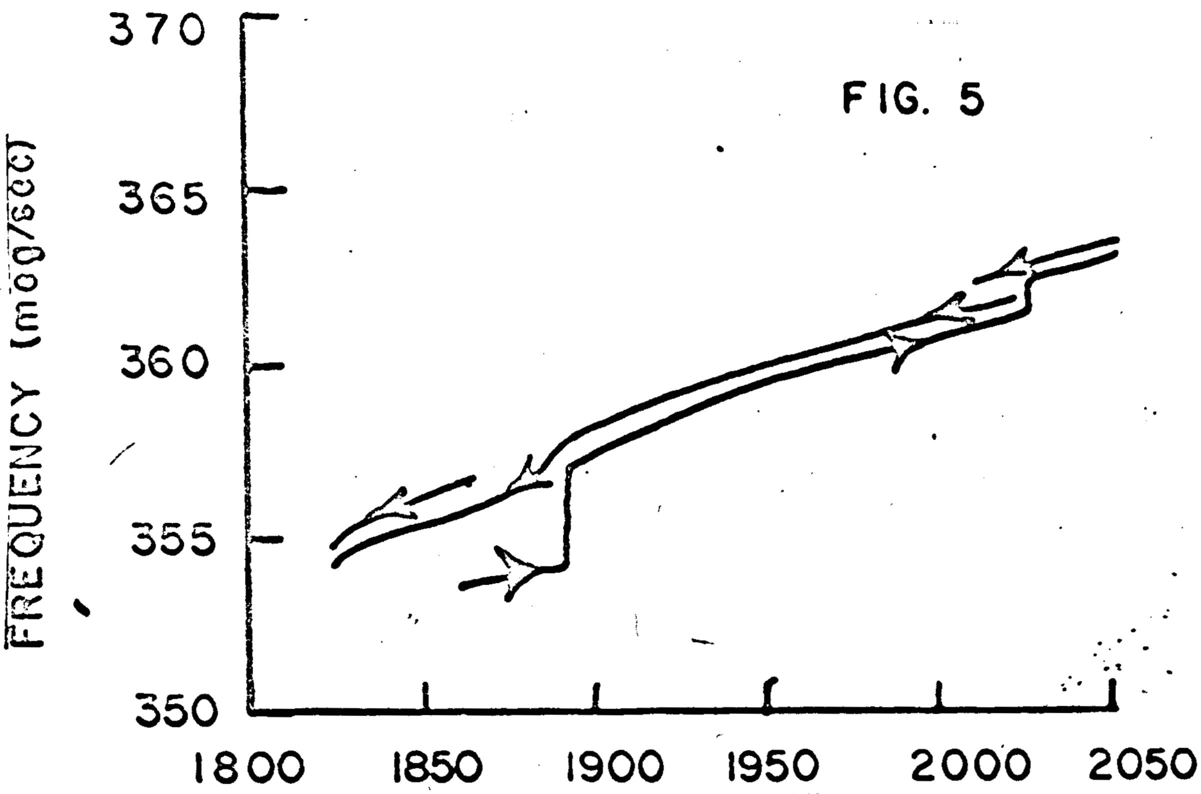
FREQUENCY (mcg/sec)
370
365
360
355
350
1800
1850
1900
1950
2000
2050

FIG. 5

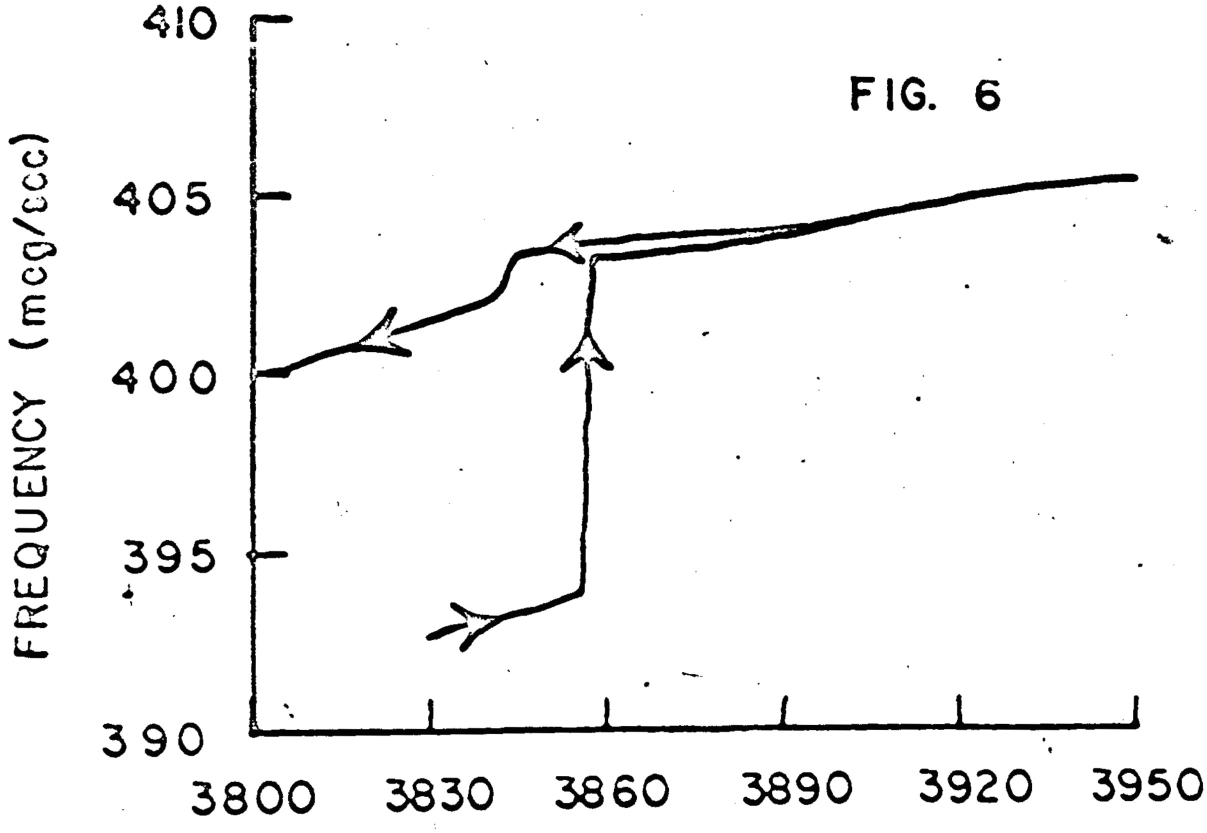
FREQUENCY (mcg/sec)
410
405
400
395
390
3800
3830
3860
3890
3920
3950

FIG. 6