MASTER CONF-761204--1

LA-UR -76-2301

TITLE: OBSERVATION OF COHERENT RESONANCE FLUORESCENCE IN HOT CO_2

AUTHOR(S): S. J. Czuchlewski, B. J. Feldman, Robert A. Fisher, A. Nowak

SUBMITTED TO: American Physical Society Meeting at Stanford, California

los alamos
scientific laboratory
of the University of California
LOS ALAMOS, NEW MEXICO 87544

Form No. 836
St. No. 2629
1/75

UNITED STATES
ENERGY RESEARCH AND
DEVELOPMENT ADMINISTRATION
CONTRACT W-7405-ENG. 36

INTRODUCTION

Hot CO_2 has often been considered as an isolator for large, short-pulse CO_2 laser systems because of the hot CO_2 line-to-line absorption coincidences with the CO_2 laser transitions. Schappert[1] first showed that in the absence of beam diameter reduction, hot CO_2 was unsuitable because of its large saturation flux. Feldman, et.al.,[2] showed that hot CO_2 is a potentially attractive baseline precursor suppressor because of the difference in the bandwidth of the undesirable baseline and the desirable short pulse. Feldman subsequently showed[3] that by reducing the beam diameter in the hot CO_2 (and therefore raising the intensity) the effective saturation parameter of hot CO_2 could be reduced so that it would simultaneously behave as a practical saturable absorber and as a pulse bandwidth-discriminating baseline suppressor.

ONE NANOSECOND PULSE RESULTS

Although hot CO_2 was originally considered for quarter-nanosecond systems[2,3], we have elected to first check our theoretical understanding by using the recently available one-nanosecond pulses from the Giga-Watt Test Facility (GWTF) in TSL-85. The results reported here are in relatively good agreement with theory. The experimental setup (as shown in Fig. 1) is as follows: a one nanosecond duration 1/2 millijoule switched-out pulse from the smoothing-tube stabilized GWTF oscillator was directed through two heated pyrex cells filled with CO_2 and fitted with NaCl windows at Brewster's angle. The cells were 190 cm long of which 160 cm were heated to 300 ± 10° C for a total heated path of 320 cm. Temperatures were measured with three chromel-alumel thermocouples on each cell. The 1 ns pulse clipper consisted of a CdTe crystal (8 mm x 8 mm x 4 cm) switched by a 13 - 16 kv pulse from a laser-triggered spark gap. The resulting pulses were detected by a Molectron P5-00 pyroelectric detector, and signals were recorded on a Tektronix 7904 oscilloscope.

Figure 2 shows typical results. Note the growth of the second peak as the CO_2 pressure is increased. Even at zero torr hot CO_2 there is a second peak; this is merely ringing in the 7904. This ringing was subtracted from each picture before evaluating the ringing due to the hot CO_2. Figure 3 shows the measured corrected ratio of the second peak to the first peak as a function of hot CO_2 pressure. This figure indicates what has already been known; that in the linear regime one must use low CO_2 pressures to reduce the undesired secondary ringing. Unfortunately, at these reduced pressures the baseline rejection will be only slight since $\alpha_0 \ell$, the absorption coefficient times cell length, is small (0.554/torr up to 5 torr). The calculated baseline reduction factor ($e^{-\alpha_0 \ell}$) is shown in Fig. 4. Note that adequate baseline reduction is not available at low pressures. This is why hot CO_2 operating as a <u>linear</u> filter was not proposed for one nanosecond systems; good baseline rejection and lack of ringing are incompatible for one nanosecond pulse durations.

Saturation of either the hot CO_2 or the subsequent amplifier chain will reduce the secondary ringing. Although the pulse did not have enough energy to saturate the entire sample length of CO_2, we telescoped the beam diameter down to see if any evidence of hot CO_2 saturation could be obtained; our results showed only a slight reduction of the second peak. The testing of saturated operation of hot CO_2 at one nanosecond will be addressed in a future experiment.

170 PICOSECOND RESULTS - PULSE COMPRESSION IN SF_6

To test the effects of hot CO_2 on pulses shorter than one nanosecond, we were first tempted to use the ultrashort pulses generated by optical Free-Induction Decay[4] (an effect also obtained in hot CO_2), but these FID pulses are characteristically different from the electro-optically switched-out pulses. The FID pulses have a narrow spectral notch missing from an otherwise broad spectrum, and there is post-pulse temporal ringing out of phase with the main lobe. In our attempt to obtain a shorter pulse we have tried to compress a one nanosecond switched-out pulse by saturating SF_6 in a short cell. The beam was telescoped down to a 3 mm diameter (corresponding to $\sim$ 5 MW/cm^2 in the one nanosecond pulse) and was passed through a 3.3 cm-long cell of SF_6 heated to 120°. Unfortunately, at this time, all Molectron detectors had been unable to meet the sensitivity originally specified, and all had been returned to the factory for repair. A Rofin photon-drag detector with slightly different ringing characteristics had to be used. After passage through the SF_6; the pulse passed through the hot CO_2 cells and then through amplifiers 1 and 2. The amplifiers were needed because of the attenuation in the SF_6 ($\sim$ 90%). Fig. 5 shows typical results obtained with 10 torr of hot CO_2 in the cells. As the pressure of the SF_6 was increased, the hot CO_2-induced ringing was reduced. Several data points were taken at each of a set of SF_6 pressures; the averaged results are graphed in Fig. 6. Again, detector and scope ringing was subtracted prior to obtaining this figure.

Although this evidence is preliminary, it is consistent with the explanation that at 18 torr, the SF_6 cell reduced the pulse duration by a factor of 6; this would have reduced the hot CO_2-induced ringing by just that same factor. In our numerical simulations in 3.5 meters of hot CO_2, the ratio of the second peak to the first is approximately 0.61 T_p/T_2, where T_p is the FW $\frac{1}{e}$ M duration of the pulse and T_2 is the homogeneous lifetime of the absorbing transition. There are, of course, other explanations which do not require SF_6 induced pulse shortening; these other possibilities must be eliminated before we can be assured that shortening does occur. We intend to carefully measure the shortening effect with the new 5 GHz scope and fast detectors.

All results obtained thus far have been free of any conflicts with our theoretical models of short pulse propagation in resonant absorbers.

REFERENCES:

1. G. T. Schappert, LASL Memorandum: L-1/75-1393, September 1975.
2. B. J. Feldman, R. A. Fisher, E. J. McLellan, and J. F. Figueira, LA-UR 75-2294 (1975).
3. B. J. Feldman, LASL Memorandum: L-2/76-45, January 1976.
4. B. J. Feldman, R. A. Fisher, E. J. McLellan, and S. J. Thomas, LA-UR 75-2321, Presented at IXth International Quantum Electronics Conference, Amsterdam, The Netherlands, June (1976), also Opt. Commun. 18, 72 (1976).

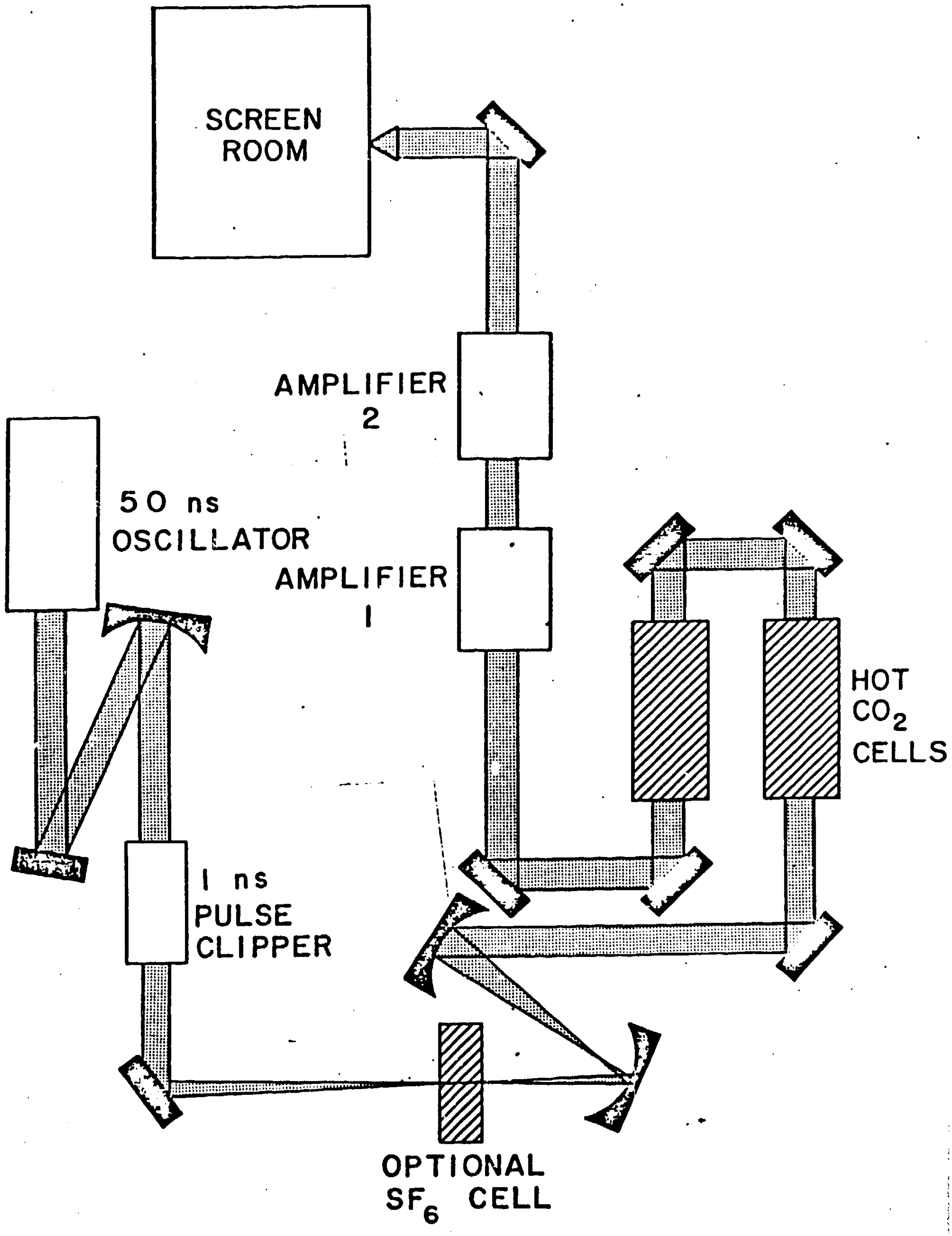

Fig. 1

Adaption of the Gigawatt Test Facility (GWTF) for Experiments - Normally the SF_6 Cell and Hot CO_2 Cells are Missing

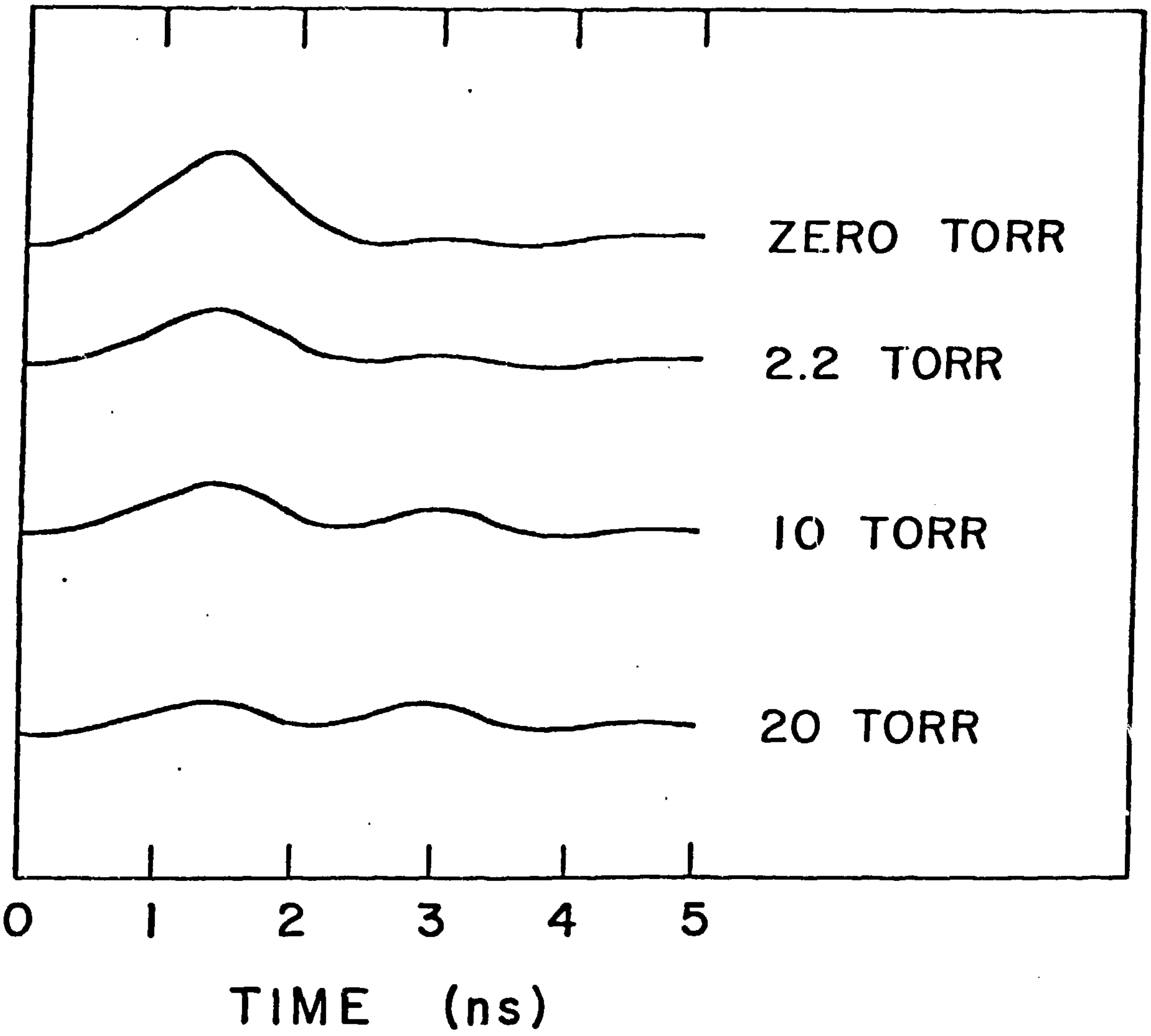

Fig. 2

Artists' Reconstruction of Oscillograms Taken to Study Ringing Introduced by Short Pulse Transmission in Hot CO_2. The Hot CO_2 Pressures Corrsponding to Each Shot are Indicated in the Figure: the cell Temperature

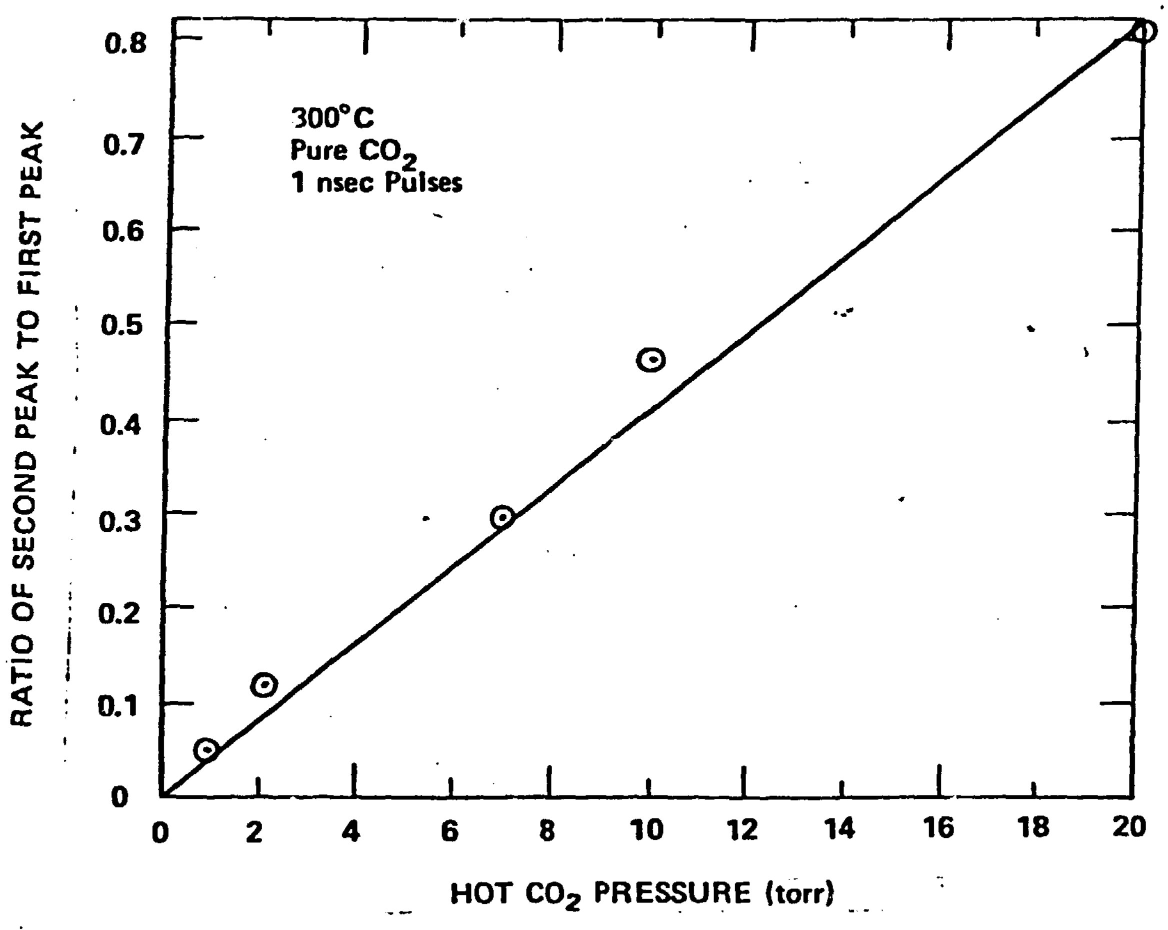

Fig. 3

Measured Fractional Height of Second Peak After Propagation Through the Hot CO_2 Cells. The Ringing in the Oscilloscope (as in the zero torr trace in Fig. 2) Has Been Subtracted

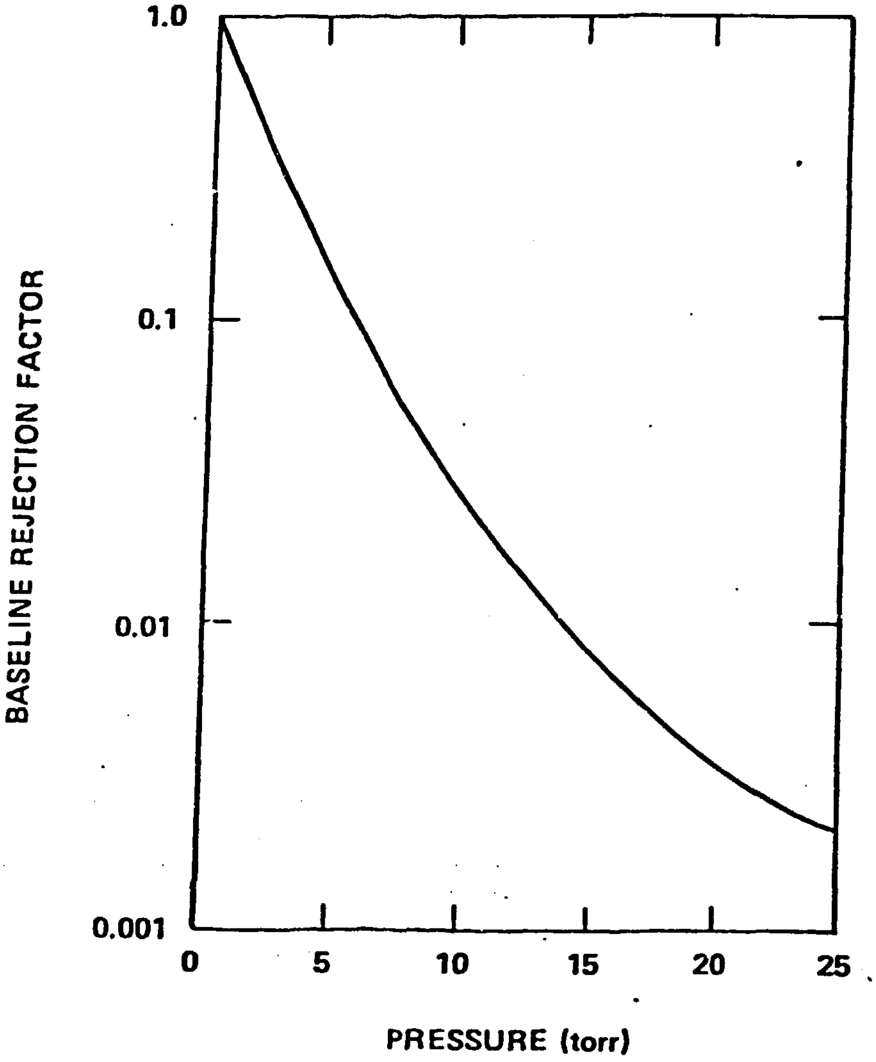

Fig. 4

Calculated Baseline Reduction Factor ($e^{-\alpha_o \ell}$) Versus Pressure in the Hot CO_2 Cells

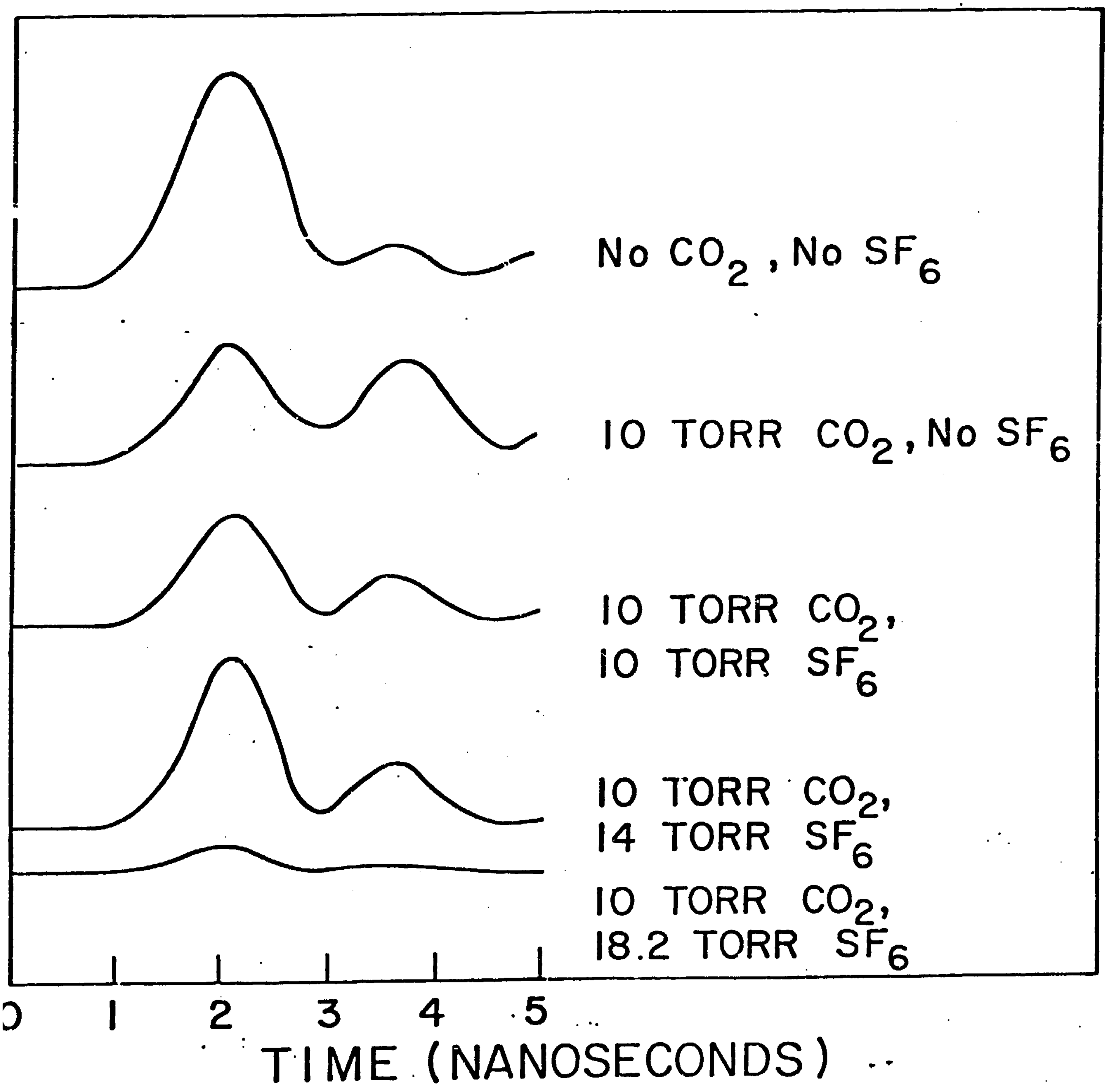

Fig. 5

Artists' Reconstruction of Oscillograms Showing the Reduced Ringing in the Hot CO_2 When the Pressure in the Preceding 3.3 cm SF_6 Cell is Increased - The Vertical Scales are Different on Each of These Traces

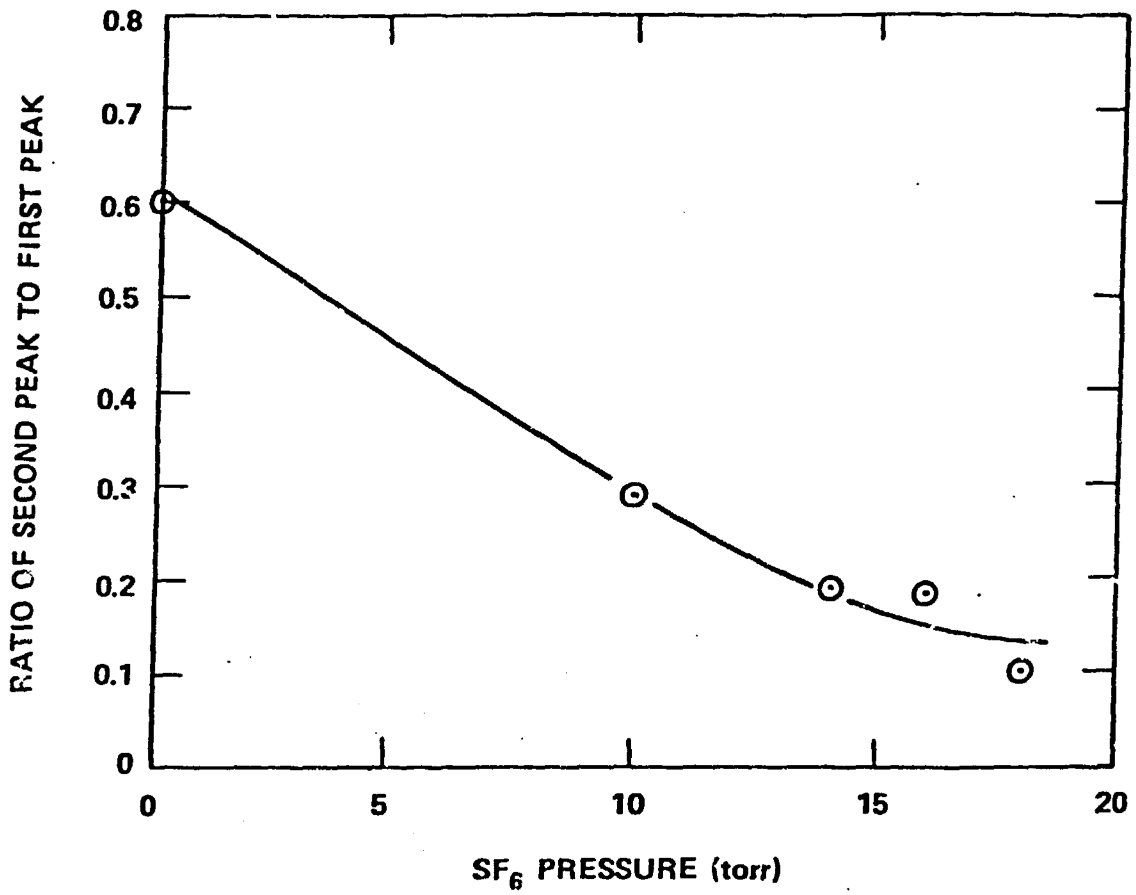

Fig. 6

Measured Ratio of Hot CO_2-Induced Secondary Peak as a Function of Pressure in the 3.3-cm SF_6 Cell (T = 49° C)