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A PRECISION APPARATUS FOR MEASURING RELAXATION IN CRYSTALLINE METALS

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INTRODUCTION

A time dependence of ultrasonic second and third harmonic upon the bias stress in Aluminium and NaCl was reported by Scorey(1,2,3). This effect can provide interesting informations about dislocations and the physical state of crystalline solids. For an exhaustive investigation it is necessary to make simultaneous measurements of amplitude and applied mechanical stress at a known time. In the present work a system has been designed to improve on the circuitry used by Scorey and enables the three parameters to be simultaneously determined. The system may be sub-divided into two sections, that of control and of analogue measurement respectively.

THE CONTROL SYSTEM

The system works on a general principle of pre-triggering an oscilloscope. This results in successive movements of the whole display across the screen of the oscilloscope one step at a time. The width of a step and the time taken before moving to the position of the next step being controllable. Only the portion of interest of the display is then intensified and it is recorded photographically.

A block diagram of the system is shown in Fig.1. The delayed pulse generator (D.P.G.) provides a fixed number of pulses delayed at a pre-set time with respect to a reference train of pulses (see Fig.2.). This continue until the set number has been reached then the next pulse will automatically be delayed further by one step and the process repeats itself. The time taken for each step can be adjusted between a few milliseconds to a few hours. In the present experiment the time was varied between 39 mS/step and 5120 Secs./step. Negative edges of the reference train of pulses from the D.P.G. were used to pre-trigger an oscilloscope while the delayed pulse output was fed into three separate generators i.e. the time marker & trigger, the gate control, and the intensity modulating generator.

THE GENERATORS

Time Marker & Trigger: This receives a second input from a continuous wave generator whose output is amplified, rectified, gated, and modulated to produce coincidence triggering-pulse and time-marker. Triggering pulses output (7), is used to trigger a gated r.f. generator and the time marker output (8), can be displayed on one channel of an oscilloscope to provide the time scale for measuring the wave velocity.

Intensity Modulator: This generates pulses of a pre-set width at a chosen time so as to intensify desired portions of the oscilloscope display.Both amplitude and delay time are adjustable.

Gate Controller: This has two outputs, one giving a control pedestal pulse with the positive edge coincident with that of the triggering pulse to the gated r.f. generator and having a width to just cover the end of the r.f. tone-burst.The other output also gives control pedestal pulses but they start earlier than those of the first output and finish later.This technique of pulse within pulse reduces the amplitude of the spikes associated with the transitions of control pulses.

THE ANALOG MEASURING SYSTEM

Radio frequency tone-bursts(4.83MHz.) were applied to a resonant body transducer via a passive composite notch-filter the output side of which was tuned to 4.83MHz. and had the Q-factor controlled by a resistor and back-to-back diodes in series.The transmission characteristic of this filter is shown in Fig.3. The back-to-back diodes limit the amplitude of the driving pulse as 'seen' by the analog gate.

A modified version of the analog gate(4) was designed.A simple series FET gate was used to pre-gate the driving signal.This occurred within a more delicately-balanced analog gate so that transitional spikes were reduced to below 5 mV. The spikes were then reduced further by a tuned amplifier following the gate.

It was sometimes necessary to investigate small changes in the fundamental echo signals with some chosen variables,e.g. temperature, biasing stress,etc.This was performed by a pulse height monitor which amplifies the echo signal with respect to a d.c. voltage level.Only the top parts of the echo signal were rectified using a pre-biased diode.

In the harmonic measuring system a composite notch-filter was used with both input and output tuned to the wanted harmonic frequency.

Finally, mechanical biasing-stress was applied via springs of known spring constants.The compression of a spring was measured by a slide potentiometer fed with constant current.

An example of the results obtained with an Aluminium single crystal is shown in Fig.4. and Fig.5.

CONCLUSIONS

The system has been used with a minimum amount of adaptation for both liquid and solid specimens.Transducers ranging from Polyvinyl Fluoride to ceramics have been tried on the system without difficulty.The sensitivity of harmonic detection was limited only by the noise present in the electrical system.It is also believed that given a suitable transducer the system could be used also for experimenting in gases.

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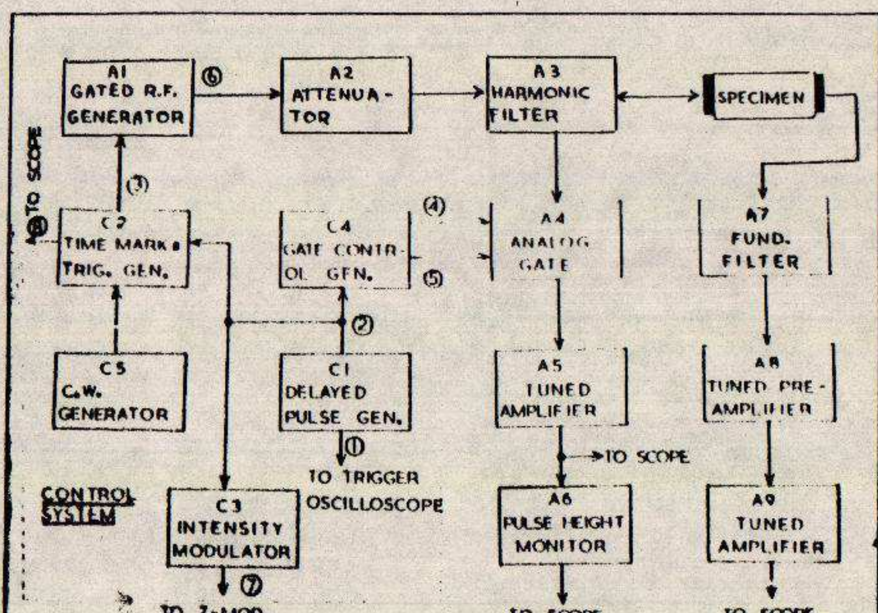

FIG.1. BLOCK DIAGRAM OF THE SYSTEM

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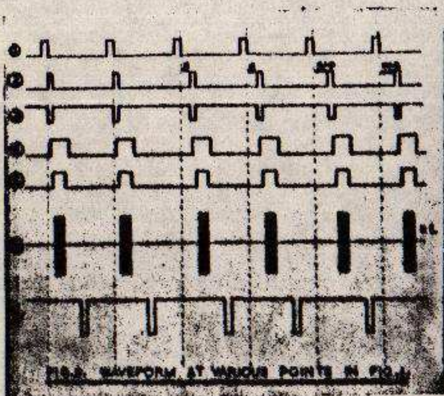

Fig.2. waveform at various points in Fig.1.

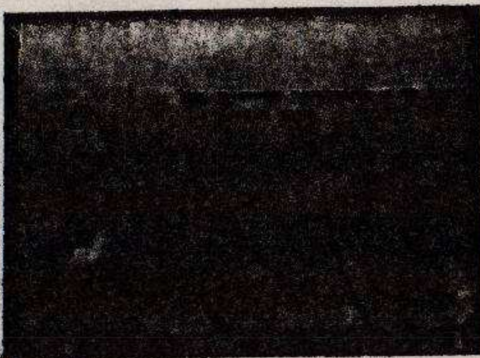

Fig.3. transmission characteristic of the harmonic filter.

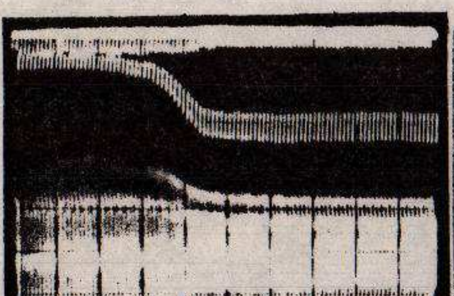

Fig.4. an example of results in an Aluminium single crystal: Top; rectified and inverted 4.83 MHz. Bottom; full 14.50 MHz. Time; 5.0 Secs. per position.

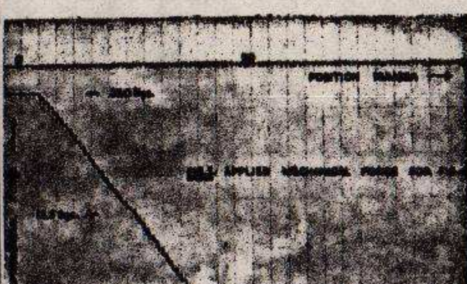

Fig.5. applied mechanical force for Fig.4.