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HIGH VOLTAGE PULSE GENERATOR

PURPOSE

The purpose of this report is to describe a method of generating a high voltage pulse of known amplitude and waveform for use in the calibration of ball gaps or other pulse voltage measurement devices.

SCOPE

This report covers the use, electro-mechanical description, and accuracy of a pulse generator in the range of 5 to 30 kilovolts and zero to peak voltage time of less than 1.0 microsecond.

1. GENERAL CONSIDERATION OF PULSE GENERATOR

- 1.1 High tension capacitor discharge ignition systems produce an initial ionizing voltage pulse to ionize the gap of the high tension igniter. The development and production of such systems require that the voltage magnitude of this pulse be measured and controlled within predescribed limits.
- 1.2 While certain types of equipment (ball gaps and voltage divider probes) have been designed to make such measurement, no standard calibration source has been made available. The usual techniques have been to calibrate pulse measurement equipment with 60 cycle AC peak or with much lower voltage than to be used and the results extrapolated. Both of these techniques lead to measurement errors since the measurement equipment is not calibrated at the same voltage and rise time levels at which it is to be used.
- 1.3 The high voltage calibrator described by this specification provides a reference standard for calibrating pulse voltage measurement equipment within the same voltage and rise time levels under which it will be used. The magnitude of the voltage pulse generated is determined with an electrostatic voltmeter; hence, it is traceable to known accuracy.
- 1.4 The pulse generator has been designed primarily for the purpose of calibrating a pressured ball gap measurement instrument. However, it may be similarly used to calibrate specific points of a voltage divider probe. The pulse generator design to be described provides the following:
 - a. Accurate output voltage.
 - b. Zero to peak voltage time to be less than one microsecond with no overshoot.
 - c. One pulsed output.
 - d. Infinitely variable from five to thirty thousand volts.
 - e. Constant waveform.
 - f. Capability of being reproduced.
- 1.5 Fig. 1 shows a photo of the pulse calibrator described connected to a pressurized ball gap. Fig. 2 shows a typical output waveform from the pulse calibrator.

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2. PROCEDURE FOR USE OF PULSE GENERATOR TO CALIBRATE PRESSURIZED BALL GAP (REF. AIR 1090)
 - a. Connect a dry nitrogen tank to the gap and adjust the pancake regulator on the ball gap to indicate 800 torr absolute pressure on the gauge.
 - b. Allow gap to purge a minimum of one-half hour to guarantee a homogeneous gas flow.
 - c. Adjust turn counting dial at front of HV pulse generator at a point sufficient to guarantee non-firing of internal switch.
 - d. Using the "HV COARSE" and "HV FINE" control knobs on the front panel of the HV pulse generator, set desired test voltage on electrostatic voltmeter.
 - e. Set turn counting dial on ball gap to the non-firing side of the test point (usually test point plus ten dial divisions).
 - f. Decrease the internal switch spacing in the HV pulse generator with turn counting dial on front panel to initiate ball gap firing.
 - g. If ball gap does not fire, repeat steps c, d, and f with test ball gap vernier set one division lower each time until ball gap fires. Repeat procedure at this setting as often as is felt necessary to guarantee that a consistent firing point has been obtained. Record this dial setting.
 - h. Proceed to check ball gap over range of 5 to 30 KV at one KV increments.
 - i. Following initial calibration or after any remedial action has been taken, a curve of kilovolts versus dial setting should be plotted and attached to ball gap.
 - j. Subsequent calibrations of the gap must maintain ± 9 dial divisions of initial data to be a valid calibration.

3. DESCRIPTION OF PULSE GENERATOR

The pulse generator is actually constructed in three portions. These are power supply and primary controls, leads and grounds, and high voltage components.

3.1 Power Supply and Primary Controls

- 3.1.1 The power supply used in the pulse generator is a commercial grade 40 KV power pack in a shielded case. Most present day commercial power supplies would probably work if, in their fabrication, good high voltage practices of connections, grounds, and internal shielding, among others were utilized by the manufacturer.
- 3.1.2 To regulate and control the output voltage of the power supply, autotransformers were used. One was a constant voltage transformer for line regulation, the others were variable autotransformers providing coarse control over the full voltage range and fine control of only several hundred volts at any setting of the coarse control.
- 3.1.3 Some means was necessary to signal the operator that the pulses were generated since the output was inaudible. A commercial audio amplifier and speaker system was installed, and an inductive pickup coil was placed in close proximity to one of the wires carrying the pulse. Thus when the generator fired, an audible click could be heard in the speaker, freeing the operator's vision for observation of the ball gap in calibration.

3.2 Lead and Grounds:

The calibrator was constructed with a one point ground made of a solid copper block into which all grounded components and leads were individually connected. Pure copper tube 1/2 in. diameter with 1/16 in. wall was used for general connections and ground wire.

3.3 High Voltage Components

These are resistors, capacitors, and the trigger switch (Reference S-1 of Fig. 3 and 4).

- 3.3.1 The capacitors used in the generator were extended planar foil capacitors. Standard Bendix capacitors were beefed up to withstand 50,000 volts DC or used as is depending upon the application. The capacitors were encased in an oil bath to insulate them from nearby metal structures and keep them thermally constant during use.
- 3.3.2 The resistors were standard, high voltage, non-inductive carbon film resistors commercially available.
- 3.3.3 The trigger switch is a three electrode controlled gap as shown in Fig. 5. The third electrode, the teaser, is a needle pointed rod of tungsten perpendicular to the axial line of the major electrodes and is insulated from them and ground.
 - 3.3.3.1 The low electrode is installed on a threaded shaft and mechanically geared to a ten turn dial indicator. All gears and shafts were spring loaded to insure repeatable gap distance for any given dial indication. One dial division moves the low electrode 416.6 microinches. At 900 dial divisions, gap spacing is approximately .375 inches.
 - 3.3.3.2 The electrodes are 1 in. chrome steel balls. The area of the balls where firing occurs and the area around the teaser were milled out and plugs of pure tungsten were inserted, brazed, and ground down to follow the contour of the ball.

4. PULSE GENERATOR ACCURACY

The accuracy of the pulse generator is presented in Table 1. Not included in the tabulation is the accuracy of the electrostatic voltmeter which is 0.5% of full scale value.

Table 1

Pulse Generator Accuracy

Standard Voltage	Losses	% Error
2,500	107.7	4.28
5,000	115.3	2.31
10,000	130.7	1.31
15,000	146.0	0.97
20,000	161.4	0.81
25,000	176.7	0.71
30,000	192.1	0.64