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TECHNICAL

GAS SAMPLING AND RECORDING SYSTEM

FRI/R142/151/163

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TITLE	:	GAS SAMPLING AND RECORDING SYSTEM FRI/R142/151/163
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SECTION	:	ELECTRONICS
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FUEL RESEARCH INSTITUTE OF SOUTH AFRICA

GAS SAMPLING AND RECORDING SYSTEM FRI/R142/151/163

PART I

SYNOPSIS

This report describes an electronic control system to record and sample the flow of gas in the DELAYED COKING APPARATUS.

INTRODUCTION

A request was made to the Electronic Section to develop an automatic gas sampling and recording system to obtain and record a sample of gas at 10 litre intervals. Three existing items of equipment, a gas flow meter, a Yokogawa fanfold chart recorder with clockwork paper advance and an induction motor driving the gas sampling mechanism, were to be linked together to form the system.

DESIGN

The primary requirement demanded that the system respond once for every 10 litres of gas passing through the gas flow meter by recording the event on the chart recorder and taking a controlled sample of the gas. It was decided to derive an electronic signal from the rotation of the digit drums of the gas flow meter and feed it to the Yokogawa chart recorder. The nature of the signal required would be a DC level with a peaked change for an event. By observation of the gas flow meter it was ascertained that the duration of a peak would vary with the flow and vary in the range of from 3 - 30 SECONDS, since the second section of the system was concerned with accurate gas sampling this signal could be used to trigger off the operation of the sampling motor.

The actual motor was of the induction type and driving a geared worm drive to a syringe. Variable speed control of such a motor is difficult and expensive, so it was decided to activate the motor on a fixed sample time. Every 10 litres of gas passing would cause the motor to run for 90 SECONDS (INITIAL TIME DURATION CHOSEN). The actual time would have to be less than the minimum period between events corresponding to the peak gas flow during a run with the Delayed Coking Apparatus. It is worth noting that the gas sample is cumulative over a period of some hours and using the triggered method of sampling would result in a very accurate sample, and that most of the sample would be collected during the peak when the carrier gas is mixed with a higher quantity of product gases.

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It was decided to make the sample time variable over the range of from 15 - 100 seconds, and to build an electromagnetic counter to record the number of times the sampling motor was activated.

DEVELOPMENT

The system was built in separate units rather than one integrated unit, and consists of a LIGHT SUPPLY UNIT, EVENT MARKER UNIT, OPTO ISOLATOR UNIT, TRIGGERED TIMER and GAS SAMPLE COUNTER.

EVENT MAKER UNIT

A photoresistor was chosen as the sensor to derive a signal from the digit drums in the gas flow meter. A small piece of alluminium foil acting as a reflector for the light from a small lamp was affixed to one segment of the units drum. The photoresistor was used as part of the circuit of an integrated circuit voltage regulator so that a change in the photorestance caused a dip in the output voltage of the recorder, typically from 9 VOLTS to 7 VOLTS. This dipping voltage was fed to the Yokogawa chart recorder and produced a satisfactory ink trace with events occurring at 10 litre intervals.

OPTO ISOLATOR UNIT

Since the best obtainable signal from the photoresistor circuit was 9 VOLTS DIP TO 7 VOLTS, it was decided to build an interface circuit which would convert this to digital logic 5 VOLTS (HIGH) to 0 VOLTS (LOW). The circuit consists of a SCHMITT TRIGGER and an INVERTER both from the 74 SERIES TTL family. Since the SCMITT goes high at +1,7 volts and low at +0,8 volts a NEGATIVE BALANCE REGULATOR was included so that the dipping signal would be 2 - 0 volts not 9 - 7 volts. The 2 volt span is sufficient to cover the Schmitt's hysteresis but improvements in the photoresistor circuit have increased the span by 98 VOLTS. Since the SCHMITT operates with a NAND function an inverter was included which serves as a buffer and the output of the unit is in TTL form 0 - 5 VOLTS.

TRIGGERED TIMER

The output of the OPTO ISOLATOR UNIT was fed to the triggered timer, the opto isolator integrated circuit being built into the input of the triggered timer. The triggered timer itself consists of a monostable pulse circuit which, when triggered by a rising voltage, gives an output for a set length of time. The

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time is dependent upon the ratio of resistance to capacitance in its timing circuit. A number of capacitors forming a range are selected individually by a rotary switch. Originally it was intended to provide a range from 15 to 100 seconds this being the sample time for the induction motor to draw its sample of gas. The high incidence of electrical noise in the operational environment caused the sample motor to run continually and considerable efforts were made over an extended period of time to make the system noise or "CLITCH" proof.

NOISE

Electrical noise has existed for as long as Electrical or Electronic technology itself. When Thermionic valves were in use, it did not have so serious an effect as it does with modern integrated circuits. The thermionic valve was crude, cumbersome and slow by comparison with integrated circuits and a large amount of integrated circuitry capable of performing complex monitoring and control functions can fit into a small space. The equivalent thermionic valve circuitry, even supposing the devices were freely available, would take up considerable space and require large power supplies to run it. The price to be paid for cheapness, availability, small size, reliability and accuracy is NOISE SENSITIVITY.

NOISE PROOFING

As stated earlier, considerable efforts were made over an extended period of time to make the system noise proof. Initially these centred on mains interference filters but when these failed, a rationalized approach was considered. Electrical noise originates from different sources and has different forms. Different types of noise from different sources can enter the circuit at different points at different times and all cause the same result - false triggering of the sample motor.

The following answers were tried cumulatively, it being assumed that each could effectively deal with certain types of noise, but because of concentricity of manifestation the efficacy of any answer would be hard to prove.

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(1) USE OF METAL MOUNTING BOXES FOR ALL CIRCUITRY.

(2) USE OF OPTICAL ISOLATION CIRCUIT IN INPUT OF TRIGGERED TIMER.

(3) TRANSORBS (NOISE CLIPPING DIODES) ON BOTH MAIN SUPPLY AND DC CIRCUIT SUPPLIES.

(4) USE OF GATE CIRCUIT CONSISTING OF A LIGHT SOURCE AND PHOTORESISTOR TO ENABLE TRIGGERED TIMER ONLY WHEN YOKOGAWA INK TRACE INDICATES AN EVENT (10 LITRES OF GAS).

(5) REDUCTION OF SAMPLE TIME FROM 100 SECONDS TO 6 SECONDS.

(6) INSTALLATION OF LEAD ACID BATTERIES AND 36 V DC TO 220 V DC INVERTER TO MAKE AN ISOLATED SUPPLY.

After no (5) (REDUCTION OF SAMPLE TIME FROM 100 TO 6 SECONDS) was incorporated it was found that the system was entirely free of noise effects and totally reliable. This was in January, 1978, and the system has worked satisfactorily ever since. It was not felt necessary to incorporate answer no. 6.

A total of 710 man hours were required for design and development and some expense was therefor incurred.

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PART II - CIRCUIT DESCRIPTION

LIGHT SUPPLY FRI 151-2

The circuit is a DC supply of 10,5 VOLTS separately fed from the mains with a small torch lamp in the gas flow meter.

EVENT MARKER UNIT FRI 151-1

A photoresistor in the GAS FLOW MOTOR being part of the control circuit of an LM 317 variable voltage regulator causes the normal 9 V output to drop to 6,7 VOLTS when 10 LITRES of GAS (EVENT) occurs. The Yokogawa chart recorder requires a lower standing voltage then 9 V and consequently records a smaller event because it is fed through a potentiometer.

OPTO ISOLATOR INTERFACE UNIT FRI/142-2

This unit contains a trimable negative balance regulator adjusted so that being fed in opposition to the event marker voltage the nett input signal is +2,0 VOLTS. When an event occurs the input signal drops to -0,8 VOLTS. This signal is then applied to a SCHMITT TRIGGER with a NAND function the SCMITT shapes the event signal and inverts it in TTL form which is then reinverted twice in the INVERTER BUFFER STAGE to appear as a TTL normally low event high at the input of the TRIGGERED TIMER.

TRIGGERED TIMER FRI/142

The TTL normally low in the LED input of the OPTO ISOLATOR is transformed optically to the photo transistor section which gives an output from the OPTO ISOLATOR of approx 1,5 VOLTS when an event (HIGH) occurs. This signal of 1,5 VOLTS lifts the inhibit (INH) on the 555 oscillator which sends a stream of pulses via the R.C. network to the input of the 555 one shot. This 555 has a range of capacitors selected for its timing circuit and will trigger if its inhibit is lifted. The event signal is simultaneously applied to the Yokogawa chart recorder and as the pen deflects to record the event a light beam is established from a small lamp to a photoresistor which forms part of a potential divider from Vcc (12 VOLTS) to earth. The photo resistor goes low and a low signal is applied to a SCHMITT TRIGGER NAND which inverts to TTL high and this is applied via a diode to the base of the relay driver BC 108 base. The BC 108 pulls the relay in,which closes the voltage circuit and lifts the inhibit on the 555 one shot. The one shot now triggers on the first incoming

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pulse from the 555 oscillator and goes into its long time deàày. Its high output is inverted twice for buffering purposes and gated into the MAC 11-8 motor drive TRIAC. The sample motor runs. The high output is also inverted twice viz HIGH, LOW, HIGH and fed through a diode to the base of the RELAY drive transistor BC 108 holding it in conduction and thus the Relay and INHIBIT circuit on the 555 one shot. The circuit is now LOCKED for the duration of the required time of sample motor run.

NOISE SENSITIVITY

Noise sensitivity is reduced since the inhibit circuits of the two 555's, which are extremely noise sensitive, are controlled electronically by low impedance circuits, a BC 108 in the case of the 555 one shot. To trigger the system 3 separate optical (LIGHT SEAM) circuits have to be made.

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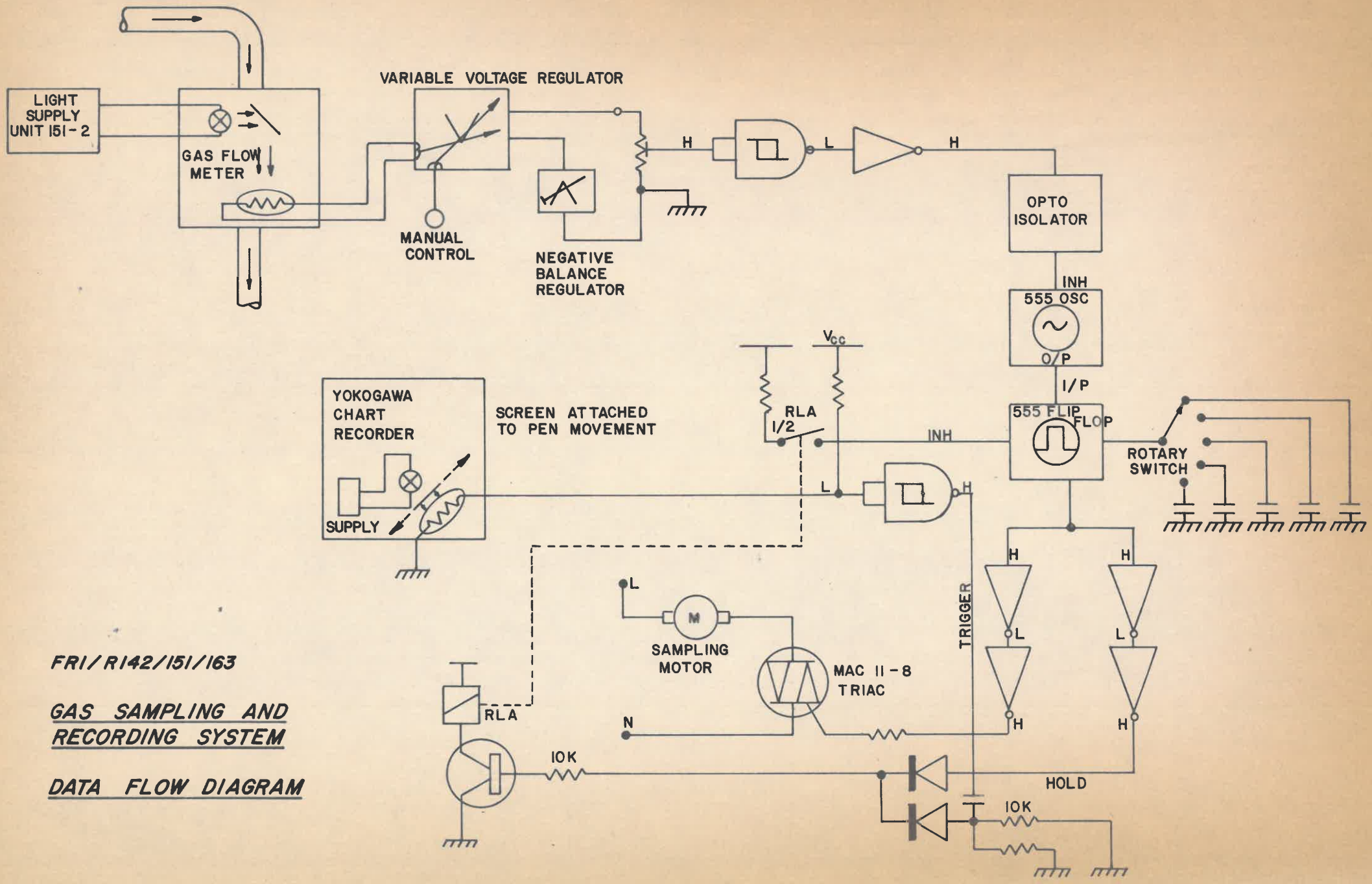

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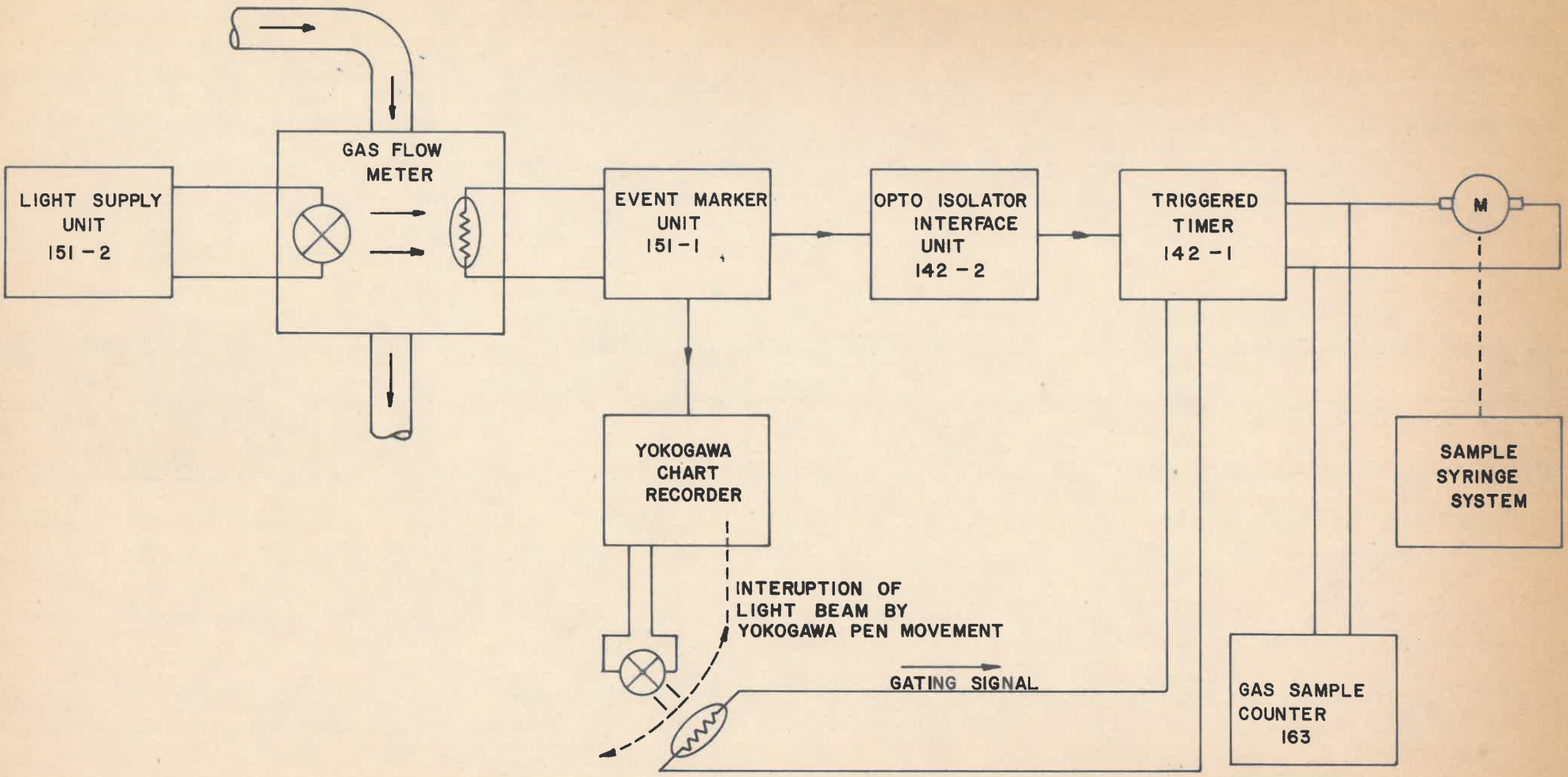
GAS SAMPLING AND RECORDING SYSTEM

DATA FLOW DIAGRAM



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GAS SAMPLING AND RECORDING SYSTEM

BLOCK DIAGRAM