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VAN SUID-AFRIKA

FUEL RESEARCH INSTITUTE

OF SOUTH AFRICA

TEGNIESE MEMORANDUM
TECHNICAL

NO. 44 OF 1973

A STRAIN-GAUGE AMPLIFIER

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1. INTRODUCTION

The amplifier to be described was developed and built as a requirement for the "Delayed Coking" apparatus constructed at the Institute. A piston pump driven by a three-phase motor is used to supply a constant volume of preheated fluid for coking. Precautions had to be taken to ensure that an overpressure does not build up to block the even flow in the event of the coking of fluid within the pumping system, thus causing damage to the pumping circuit. An early alerting system therefore became necessary.

2. METHOD OF CONSTRUCTION

Four strain gauges connected in bridge form were attached to a flange on the pump. The position where the strain gauges were attached was chosen in such a way that the maximum strain forces could be detected and noted. However, the electrical signal resulting from the strains which the bridge elements are subjected to, was so weak that it could not be detected readily by any existing equipment. It was consequently decided to employ an operational amplifier to amplify the signal from the strain-gauge bridge to such a degree that it could be registered by a moving coil meter having a full-scale deflection of ~~0,2~~ 2,0 mV. After experimenting, it was found that the maximum signal obtainable from the strain-gauge bridge was in the order of 0,002 mV. An amplification factor of 1000 had to be employed. For this purpose a "Fairchild" type UA 725 operational amplifier was chosen.

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In Figure I, the section shown within the dotted lines is the measuring bridge and amplifier circuitry.

(i) Stabilised power supply and measuring circuits

The section below the dotted lines is a stabilised power supply, employing a "Fairchild" type UA 723 precision voltage regulator. This circuit supplies a stabilised voltage across the measuring bridge. Switch S2, meter M2 and shunt Sh provide for the checking of the bridge current and the potentials of B1, B2, B3 and B4 by rotating the switch to the respective positions. Markings on the dial of M2 indicate the correct bridge current and also the maximum lower limit of the battery potentials.

(ii) Amplifier circuitry

The D.C. input voltage to the measuring bridge and also its output to the amplifier are supplied via leads as well as screened leads from the amplifier/ power supply unit housed in a metal cabinet. The resistors R2, R3, R4 and capacitors C2 and C3 are the biassing and stabilising arrangement. R5 and R6 serve to limit current and also form part of the negative feedback. R1 is the main feedback resistor which determines the gain of the amplifier, whilst C1 affords frequency compensation. M1 gives a full-scale deflection for 100 lbs/sq. inch and decreases linearly and proportionately with decreased pressure on the strain gauges, i.e. decreased pressure from the pump.

/(iii) .....

(iii) Switch S1 a, b and c

The "a" section of the switch switches on the power to the transformer; the "b" section applies battery to the operational amplifier, whilst the "c" section controls the sensitivity of the meter M1. This was done to prevent excessive meter deflection with consequent damage to the meter in the event of a large unbalance signal to the input of the amplifier. The bridge is balanced by means of RV1 and RV2 across one arm of the bridge. Once balance has been obtained, i.e. when the meter needle indicates 0, the switch S1 is set to the third position, marked "measuring", and left in this position for the period during which the apparatus is operative.

(iv) Operating instructions for the amplifier

(a) Make sure that the strain-gauge bridge is connected to the amplifier and no pressure is exerted by the pump;

(b) Set the "balance/measuring" switch to the balance position.

(c) Check the deflection of the strain measuring meter, and adjust to zero by means of the coarse and fine zero knobs. At this stage, also ensure that the switch "check 1 bridge" and "check voltage B1-B4" is at the "check 1 bridge position". The meter concerned must indicate a centre scale reading, thus indicating the correct measuring bridge current. Subsequently, batteries B1-B4 should be checked by rotation of the same switch to ensure that the batteries are still commissionable. This is

/indicated .....

indicated by a meter deflection within the coloured zone on the meter scale. Rotate the switch back to the "Check 1 bridge" position.

(d) Allow 30 minutes stabilising time and finally set the switch "balance/measure" to the measuring position.

(e) Any meter deflection below or above zero is subsequently trimmed to zero by the "zero fine" control. The apparatus is now ready for use.

(f) Always switch off the amplifier after use to prevent unnecessary battery drainage.

3. GENERAL COMMENTS

(i) Batteries are used to power the operational amplifier, to prevent any sporadic fluctuations from the strain measuring meter. Such fluctuations are usually mains-borne and could result if a mains-driven power supply were used instead of batteries.

(ii) After the necessary stabilising period, the apparatus was tested and found to work satisfactorily and without complications.

(iii) The valuable suggestions made by Dr. T.C. Erasmus and the assistance rendered by him during the development and construction of the apparatus are gratefully acknowledged.

/Component .....

COMPONENT LIST FOR STRAIN-GAUGE AMPLIFIER

Resistors

R1, R2:	47KΩ¼W Metal film.	
R4, R5:	1KΩ¼W " "	
R3:	470Ω¼W " "	
R6:	68KΩ½W 5% Cracked carbon.	
R7:	1,2KΩ½W " " "	
R8:	7,2KΩ" " " " "	(6,8KΩ+470Ω)
R9:	1KΩ " " " " "	
R10, R11:	12,2KΩ½W " " " "	(10KΩ+2,2KΩ)
RSC:	5Ω3 Watt wire wound.	
SH:	200 m V Shunt Nichrome.	
RS:	Strain gauges (Nominal resistance value 120 ohms).	

Variable Resistors

RV1:	100KΩ± 2% (Zero bridge coarse) Colvern 450l/15.
RV2:	5KΩHelical pot ten turn (zero bridge fine) Bourns.

Capacitors

C1:	180 pf. Silvered Mica.
C2:	220 pf. Ceramic.
C3:	100 pf. Ceramic.
C4:	4 mfd. 25 Volt electrolytic.
C5:	82pf. ~~Styroflea~~ Styroflex.
C6:	4Mfd. 64 Volt electrolytic.
C7:	1000mfd. 16 Volt electrolytic.

Rectifiers

RB1:	Silicon rectifier type BY 164 Phillips.

Meters

M1:	100 ~~ADC~~ M.D.C. 6" scale (Pressure indicator).
M2:	0-1/mA. D.C. 4" scale (Bridge current/battery voltage indicator).

/Switches .....

Switches

S1: Triple-pole 3-position rotary switch (make before break).

S2: Double-pole 5-position rotary switch (break before make).

Batteries

B1-B4: VARTA TYPE PX9 9 Volt 1.E.C. 6F100

Semi Conductors

Q1: Fairchild type µA725 Instrumentation operational Amplifier.

Q2: Fairchild type µA723 Precision Voltage Regulator.

Transformer

T1: Douglas Universal step down type MT79.

Primary: 0,210,240 Volts.

Secondary: 0,12,15,20,24,30 Volts @ 1 Amp.

Fuses

F1: ~~Pond~~ Panel-mounted cartridge-type ~~Belgin~~ Bulgin 0,5 Amp.

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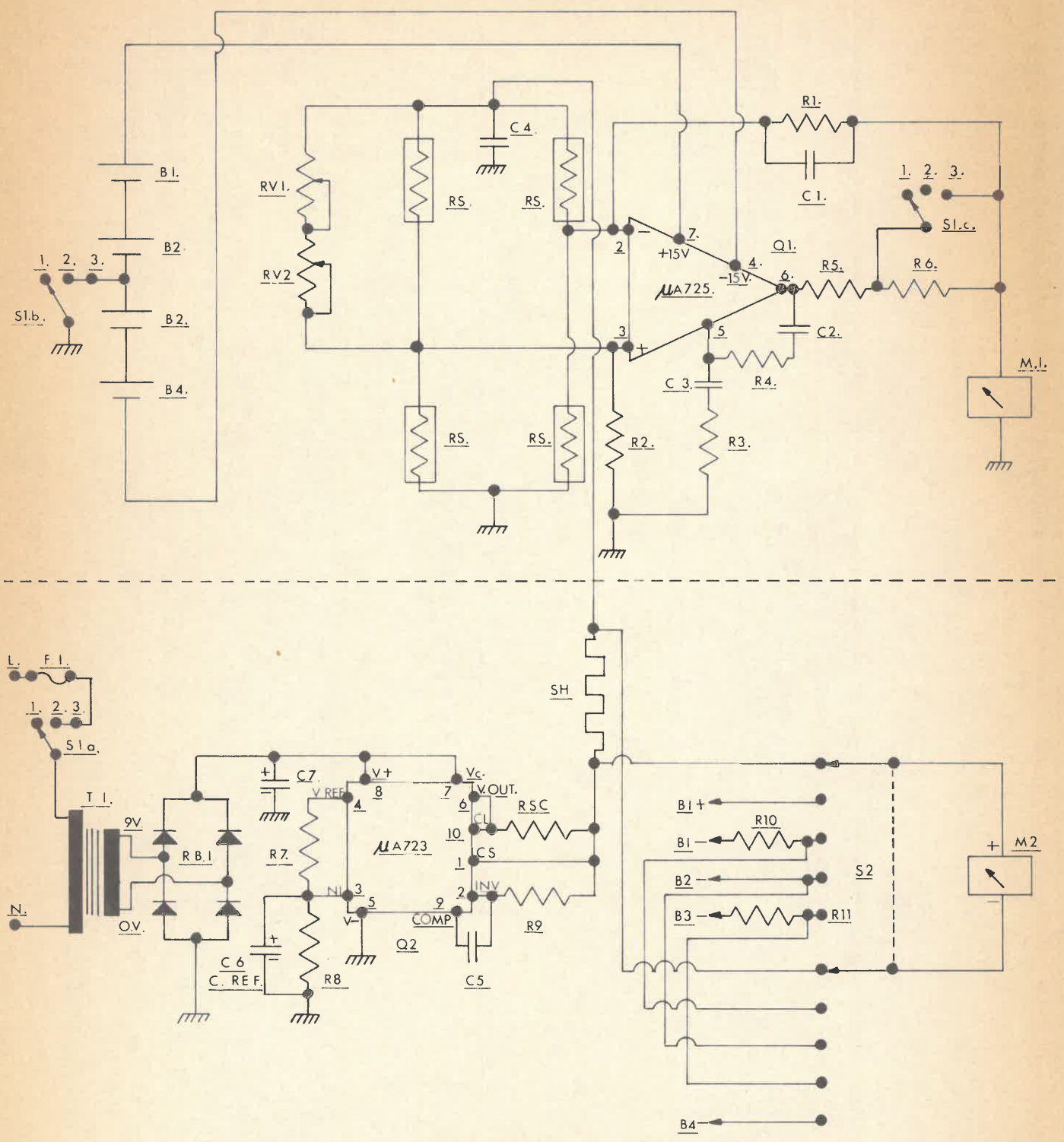
STRAIN GAUGE AMPLIFIER



CONSTANT VOLTAGE SOURCE

FIG. 1