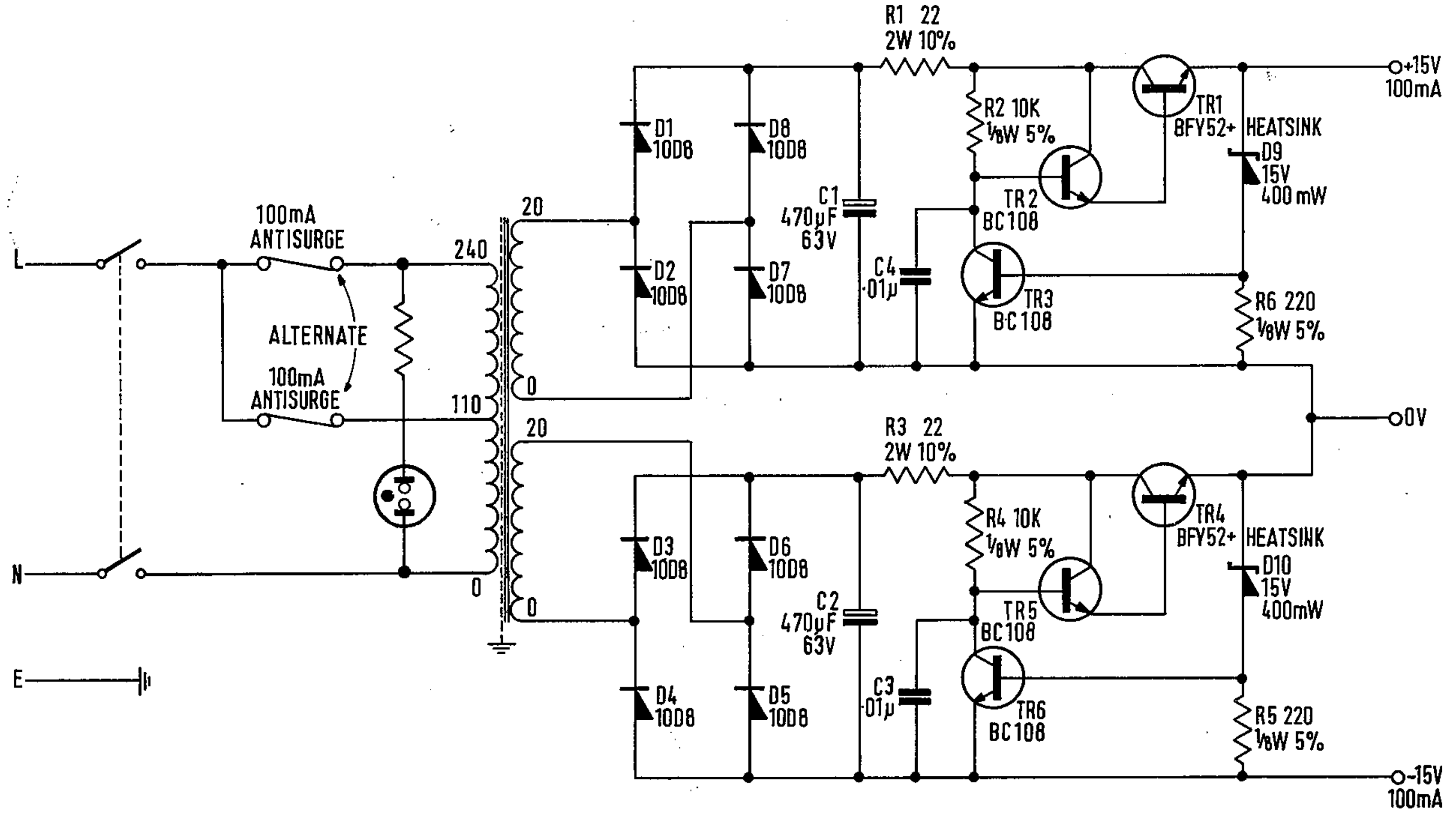


FEEDBACK LTD.

PCS 327 POWER SUPPLY-CIRCUIT DIAGRAM

4-327-5082 ISS. 3

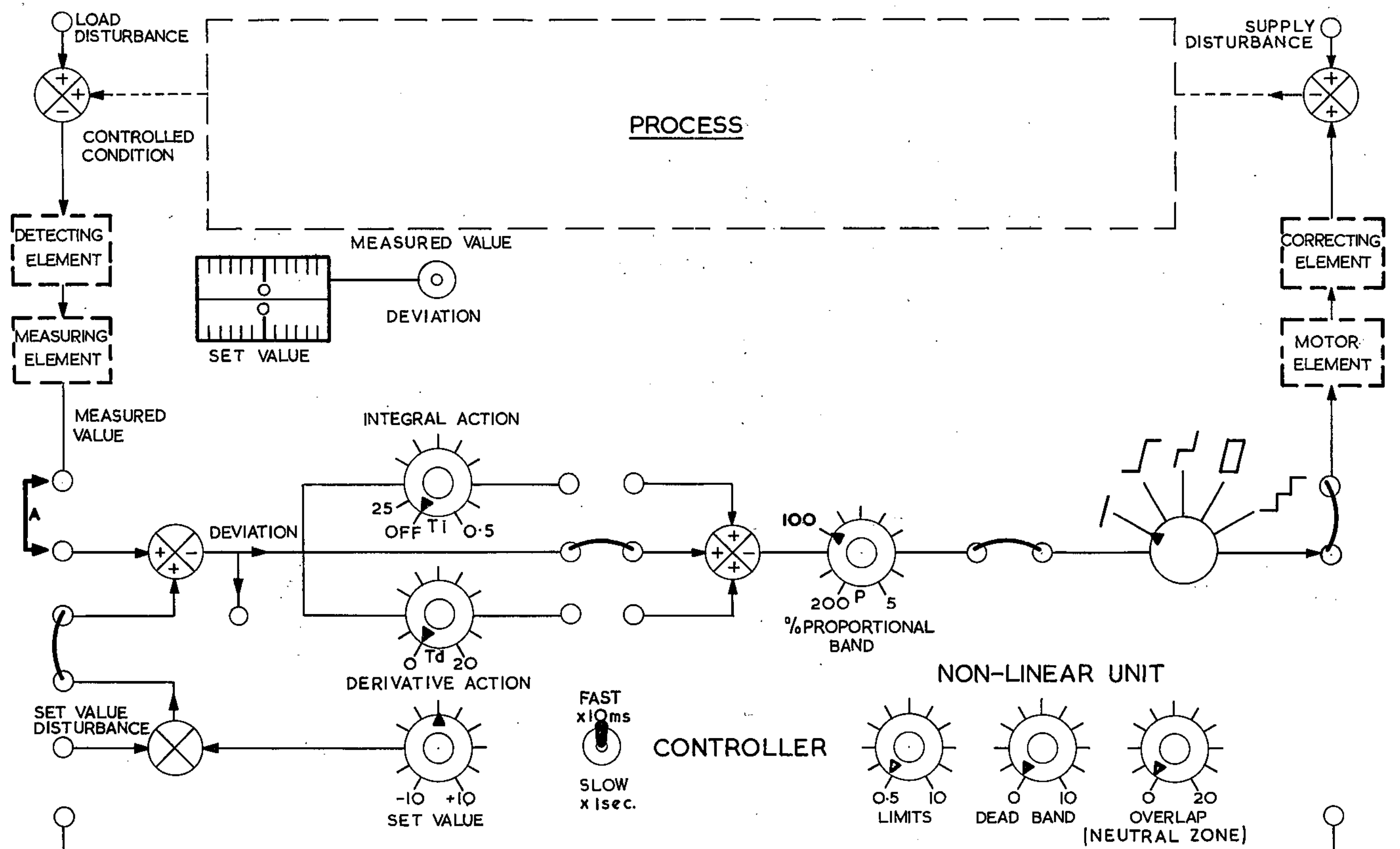

LOAD DISTURBANCE
CONTROLLED CONDITION
PROCESS
SUPPLY DISTURBANCE
DETECTING ELEMENT
MEASURING ELEMENT
MEASURED VALUE
DEVIATION
SET VALUE
CORRECTING ELEMENT
MOTOR ELEMENT
MEASURED VALUE
A
DEVIATION
INTEGRAL ACTION
25
OFF
Ti
0·5
0
Td
20
DERIVATIVE ACTION
100
200
P
5
%PROPORTIONAL BAND
NON-LINEAR UNIT
SET VALUE DISTURBANCE
-10
+10
SET VALUE
FAST x10ms
SLOW x1sec.
CONTROLLER
0·5
10
LIMITS
0
10
DEAD BAND
0
20
OVERLAP (NEUTRAL ZONE)

FIG 29

FREQUENCY RESPONSE MEASUREMENTS — APPENDIX I

It has been seen in the foregoing experiments that open-loop systems are difficult to control, closed loops are more stable but can under certain conditions become unstable. The purpose of control is to produce stability and it cannot therefore be assumed that closing a loop will give the required stability to a system.

A process and its controller consist of elements many of which cause lags and also attenuate the control signals.

These control signals are seldom constant for any appreciable period of time and will always consist of a wide range of sinusoidal signals at different frequencies and amplitudes all present at the same time.

If an open-loop system is tested to find the attenuation and time lag or phase shift for each of the frequencies to which it is capable of response, it should be possible to predict what will be the performance when the loop is closed. It may be possible to have a set of conditions such that the phase shift between input and output is 180° and the gain of the controller is equal to the attenuation of the system. Closing such a loop would produce a system providing its own input which would go into continuous oscillation, precisely the condition that is not required. The following experiment is to predict such a set of conditions so that the result on closing the loop is not instability.

EXPERIMENT 12 — OPEN LOOP FREQUENCY RESPONSE

Patch the front panel of the PCS327 as in fig 29.

Set all controls and switches as indicated.

Inject into the SET VALUE DISTURBANCE socket a range of sinusoidal input at 5V peak to peak 10-40Hz.

For each of these frequencies measure $\frac{V_{out}}{V_{in}}$ and the phase shift between V_{out} and V_{in}.

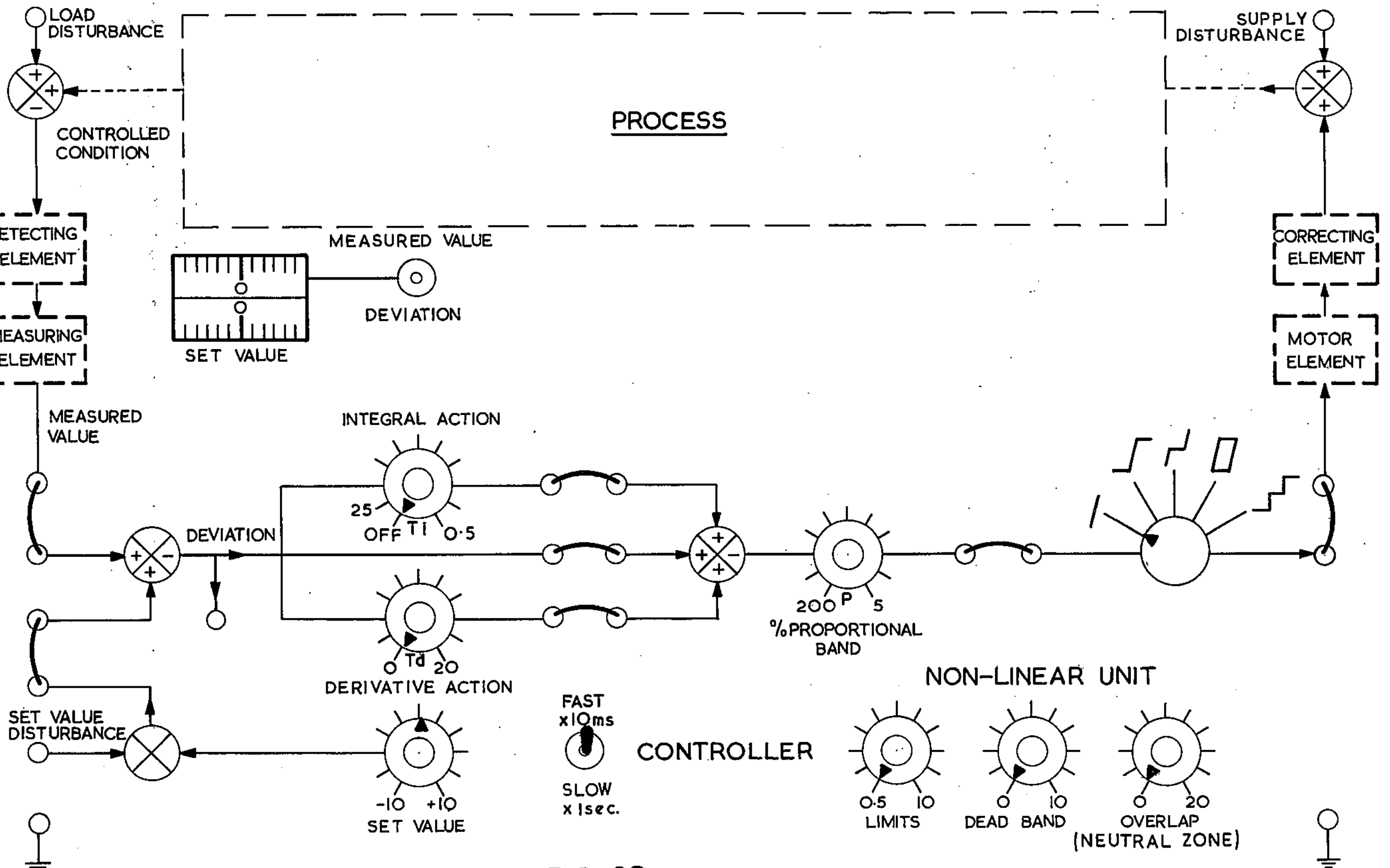
From these results make a polar plot of the amplitude ratio and phase shift.

Remove the input test signal and close the loop by inserting link A in fig 29.

Increase the controller gain by reducing the percentage PROPORTIONAL BAND until, with slight movement of the SET VALUE control, the system will go into continuous oscillation.

Note this gain setting and measure the frequency of oscillation.

Compare these values with those on the plot where it crosses the 180° axis.



LOAD DISTURBANCE
CONTROLLED CONDITION
PROCESS
SUPPLY DISTURBANCE
DETECTING ELEMENT
MEASURING ELEMENT
CORRECTING ELEMENT
MOTOR ELEMENT
MEASURED VALUE
SET VALUE
DEVIATION
MEASURED VALUE
INTEGRAL ACTION
25
OFF
TI
0·5
DEVIATION
0
Td
20
DERIVATIVE ACTION
200
P
5
% PROPORTIONAL BAND
NON-LINEAR UNIT
SET VALUE DISTURBANCE
-10
+10
SET VALUE
FAST x10ms
SLOW x1sec.
CONTROLLER
0·5
10
LIMITS
0
10
DEAD BAND
0
20
OVERLAP (NEUTRAL ZONE)

FIG 30

Some Empirical methods of Setting Process Controllers

All the following methods are based in two preliminary measurements, namely the percentage PROPORTIONAL BAND required to give continuous oscillation with proportional control only and the period of such oscillation.

For each of these methods the following terms are used:-

P_o = % proportional band that causes oscillation, proportional control only.

P_1 = % proportional band to be set.

T_i = Integral Action Time.

T_d = Derivative Action Time.

T_o = Period of oscillation proportional control only.

Each of these methods may be employed on the PCS327 and the response to a step input studied.

EXPERIMENT 13 CONTROLLER SETTINGS

Patch the front panel of the PCS327 as in fig 30.

Set all controls and switches as indicated.

Measure P_o and T_o.

Apply to the SET VALUE DISTURBANCE socket a square wave input 5V peak to peak at 2.5Hz.

Display the MEASURED VALUE.

Set up the controller by each of the following methods and confirm the points made in the text.

ZEIGLER AND NICHOLLS (THREE-TERM CONTROLLER)

Measure P_o and T_o.

Set $P = 1.67\,P_o$

$T_i = T_o/2.$

$T_d = T_o/8 = T_o/4 \quad \therefore \quad \frac{T_i}{T_d} = 4$

ATKINSON (THREE-TERM CONTROLLER)

Measure P_o and T_o

$$\text{Set } P = 2P_o$$
$$T_i = T_o$$
$$T_d = T_o/5 \qquad \therefore \frac{T_i}{T_d} = 5$$

These settings should give a response with M = 1.3, i.e the amplitude of the closed loop output should at the resonant frequency be 1.3 times that at zero frequency.

This can be checked either by normal frequency response measurements or by studying the step response which should give an overshoot of approximately 20%.

YOUNG

Proportional Only

Increase P from P_o until the subsidence ratio is about e : 1 (approx 3:1) and call this value P_x.

The maximum offset (STEADY STATE DEVIATION) that can occur is $\frac{P_x}{2}$ % of full scale.

If this is unacceptably large but a reduction to $\frac{P_x}{3}$ % would suffice, add derivative term which will then allow the percentage PROPORTIONAL BAND to be increased to reduce offset.

In any case add derivative term if the response is too slow.

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Proportional + Derivative

When derivative term is added the period of the oscillation will reduce to about $0.8T_o$.

$$\text{Initially set } T_d \text{ to } \frac{1}{10} \text{ period} = \frac{0.8T_o}{10} \qquad \therefore \frac{T_o}{T_d} = 12$$

Then to reduce P to give a subsidence ratio of 3:1.

If the offset is still too large, the period too long or the reduction of disturbances insufficient, T_d may be increased; at each stage P should be reset to give a subsidence ratio of 3:1.

T_d should not be increased above $\frac{T}{4}$ where T is the period of the damped oscillations.

Proportional + Integral

If the offset cannot be reduced to an acceptable level with proportional term only integral term can be added.

This will increase the natural period by between 10 and 30%.

Initially set T_i to be equal or less than T_o and adjust P to give a subsidence ratio of 3:1.

<u>Proportional + Integral + Derivative</u>

To obtain a required response both integral and derivative terms can be added. As the derivative term T_d is added T_i should be reduced to maintain $T_i = T$ where T is the period of damped oscillations.

Young gives no specific figures for the relationship between T_i and T_d.