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No 1052

GAS EXPLOSIONS IN BUILDINGS PART VI
REMOTELY CONTROLLED GAS SAMPLING PROBE
AND CLOSURE VALVES FOR A GAS EXPLOSION CHAMBER

by

I G Buckland, R N Butlin and D J Annable

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FIRE
RESEARCH
STATION

Fire Research Station
BOREHAMWOOD
Hertfordshire WD6 2BL

Tel: 01 953 6177

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SUMMARY

The Engineering Services Section have designed in collaboration with ITH Section, a new Sampling Probe System for the 28 m^3 explosion chamber at Cardington.

The system is remotely operated with digital indication of the probe position. The gas mixture in the cell can be sampled at any point between the ceiling and the bottom of the extended probe. After filling the chamber the probe is retracted, thus avoiding the possibility of the probe affecting the characteristics of an ensuing explosion.

All the gas inlet and exhaust valves on the rig are remotely operated using the same power source for reasons of safety and convenience.

Department of the Environment and Fire Offices' Committee
Joint Fire Research Organization

FOREWORD

Following the Ronan Point disaster and the report of the Investigating Tribunal, it was decided that the Fire Research Station of the Building Research Establishment would undertake a study of gas explosions in large compartments. In particular, the study would cover the factors affecting the development and severity of the explosions and the extent to which the pressures obtained could be relieved by venting.

In the context of the problem as a whole, the study is intended to provide the basic data on the form and magnitude of the transient stresses likely to be experienced by buildings in the event of gas explosions involving one or more compartments. This information is required as a guide for safe structural design and for any reappraisal of the relevant parts of the Building Regulations 1972, Part D, England, or Building Standards (Scotland) (Consolidation) Regulations, 1971.

Initial studies in this programme are concerned with explosions in a single compartment of realistic dimensions 28 m^3 (1000 ft^3) provided with a single opening of simple configuration, the size of which can be varied and which can be closed with panels having a range of bursting pressures.

In view of the progressive change to natural gas, which is lighter than air, and the probable circumstances of the Ronan Point explosion, special emphasis is placed on the explosion of layered gas/air mixtures and the effects of layer depth, composition and point of ignition.

The principal measurements consist of high-resolution pressure-time records at points both inside and outside the compartment. In general, these pressure records are complex, including both positive and negative pressures, and attention is given to the exclusion of spurious effects due to mechanical vibration and transient heat pulses accompanying the explosion.

The study is to be extended to gas explosions in multiple compartments communicating by door openings and corridors. Here, particular attention will be given to the effects of turbulence generated at openings, bends and obstacles and the possibility of pressures increasing as explosion propagates from one compartment to another.

This series of notes comprises detailed accounts of phases of the work as it proceeds. A project of this magnitude necessarily involves a considerable amount of preliminary work in the development of equipment and procedures, all of which need to be placed on record, but, in isolation, may sometimes appear somewhat remote from the objectives. This foreword is intended to facilitate the presentation of the detailed material with a minimum of introductory matter - no more than is needed to indicate the place of the particular work reported in the project as a whole. Reports of results and conclusions from this study will be included in the series at appropriate stages as the work proceeds and, correspondingly, these will need to contain a minimum of experimental detail.

Reports preceding the present one in the series are:

Gas Explosions in Buildings:-

Part I	FR Note 984	Experimental explosion chamber P S Tonkin and C F J Berlemont
Part II	FR Note 985	Measurement of gas explosion pressures S A Ames
Part III	FR Note 986	A rapid, multi-channel, automatic chromatographic analysis system R N Butlin, S A Ames and C F J Berlemont
Part IV	FR Note 987	Strain measurements on the gas explosion chamber M Senior
Part V	FR Note 1004	Production of gas layers for large scale gas explosion studies - preliminary investigations R N Butlin

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INTRODUCTION

It is necessary for explosion tests to monitor the production of a layer of combustible gas/air mixture in the explosion chamber[1] and determine its depth, by sampling and measuring the composition of the gas/air mixture at appropriate sites.

Any system of sampling probes remaining in the explosion chamber after ignition could introduce turbulence[2] and therefore affect the pressures generated by the explosion in an indeterminate manner. A probe was therefore designed which could be sited at the desired level in the chamber, and retracted, from a remote location.

Although a totally pneumatic system would be cheaper, the compressibility of gas is a major disadvantage as it would cause oscillations of the probe when positioning it in the explosion chamber. This effect is avoided by having that part of the system operated hydraulically and investigation indicated that such a combined pneumatic/hydraulic system was feasible.

The experiments call for accurate positioning of the gas sampling probe and its complete retraction on conclusion of sampling to avoid any turbulence it might generate, affecting the explosion.

The system was designed so that it not only satisfied the above requirements, but also provided pneumatic power, to operate pneumatic valves which replaced the existing manually operated ones.

GENERAL DESCRIPTION

The gas sampling probe consists of a hollow stainless steel cylinder of 57 mm o.d. and length 1.66 m, inside which were installed six stainless steel gas sampling tubes, 8 mm o.d. These are radially displaced at 30° between adjacent tubes, the lower ends of which after bending through a right angle exit flush with the stainless steel cylinder at 300 mm vertical intervals.

At the probe head (Fig 2) the gas sampling tubes emerge from the stainless steel cylinder and are fitted with crimped ribbon flame arresters. Flame arresters are incorporated into the system, to stop any flames propagating to the gas analyser[3], should an explosion occur during sampling.

Remotely operated solenoid valves are connected to the downstream side of the flame arresters; these are left open during sampling and closed just prior to initiating an explosion. The outlet ports of the solenoid valves are connected to the gas analyser through 6.5 mm bore butyl rubber tubing.

The stainless steel cylinder of the probe is sealed at both ends with screwed in plugs. The plug at the top of the cylinder is connected to a hydraulic actuator by means of a pinned adaptor. All joints on the gas sampling probe are made gas tight, and the exterior of the steel cylinder has a ground and polished finish to ensure that it will not damage the special gas seals contained in the seal housing (Fig 3).

The hydraulic cylinder is attached to the probe mast by mounting plates at a height such that the probe can be fully retracted from the explosion chamber. The probe mast also supports two air/oil reservoirs, a 5-port valve and a shuttle valve required for operating the pneumatic/hydraulic system.

The 4.1 m high probe mast is supported and braced on an 'H' shaped frame which is bolted to the cross members of the explosion chamber (Fig 1a and 1b). To eliminate any radial turning movement when the gas sampling probe is operated, a peg and track is fixed to the gas sampling probe and probe mast.

The gas sampling probe was supported over the centre of the chamber. No provision was made for other sites as experiments had shown that the gas concentration was basically the same throughout any horizontal plane[4].

OPERATIONAL PROCEDURE

The gas sampling probe is remotely operated from a control panel (Fig 5) in a control room 14 m from the explosion chamber via an intermediate station housing solenoid valves (Fig 6) controlling the flow of compressed air.

The pneumatic/hydraulic system for operating the gas sampling probe is shown diagrammatically in Fig 4. The control panel, contains a three way electrical switch with a central off position and selection of either of the other two positions will raise or lower the probe by activating a 3-port solenoid valve in the intermediate station. This switches compressed air of pressure 414 $kN.m^{-2}$

to one side of the 5 port valve and shuttle valve located on the probe mast, the operation of which allows the flow of low viscosity hydraulic oil to and from the hydraulic cylinder and thus provides movement of the probe. Displaced oil from the hydraulic cylinder is stored in the two air/oil reservoirs, where the flow of oil is controlled by a spring-return 'poppet' valve and a flow regulator.

When the gas sampling probe has reached the desired depth in the explosion chamber, the 3-way electrical switch is moved to its off position, which results in the loss of compressed air from the air/oil reservoirs causing the 'poppet' valves to spring shut. The flow of oil is therefore prevented and the probe locked in position.

The depth of the gas sampling probe is monitored and an electric current transmitted to the control room where its magnitude is displayed on a digital panel meter (Fig 5). The electric current was produced by a commercially available capacitance sensing electrode fitted inside the air/oil reservoir labelled A (Fig 4). As the level of oil changes due to the raising and lowering of the probe, the capacitance also varies proportionately; where the variations are transmitted as an electrical current to the control room where it is filtered, amplified and then displayed on a digital panel meter, calibrated to indicate the position of the probe.

The operating speed of the probe can be varied by adjusting the hydraulic flow regulator. Typical operating times are 83 s for raising and 51 s for lowering the probe.

The indication on the digital panel meter becomes steady 15 seconds after the probe movement stops due to a hysteresis effect brought about by the oil level slowly coming to equilibrium.

THE REMOTELY OPERATED PNEUMATIC CLOSURE VALVES

These valves replaced the manually operated gate valves referred to previously[1]. Four 3 in BSP diaphragm operated pneumatic ball plug valves are fitted to inlets and outlets on the explosion chamber at the inlet pipe at the centre of the back of the explosion chamber, at the outlets one on each side of the explosion chamber and at the purging fan connection on the side of the explosion chamber nearest the control room. They are actuated by compressed air, controlled by solenoid valves situated in the intermediate station (Fig 6). The solencid valves are energised by 2-way electrical switches incorporated in the control panel (Figs 5 and 7).

An indicator system based on light obscuration by the movement of the valves shows in the control room when the valves are open or closed. Figure 8 shows the device fitted to a valve and Fig 9 is a diagram of the electronic circuit used.

A solid state switch of this kind was necessary, since if a mechanical switch had been used, there would be a risk of arcing which could ignite the gas mixtures.

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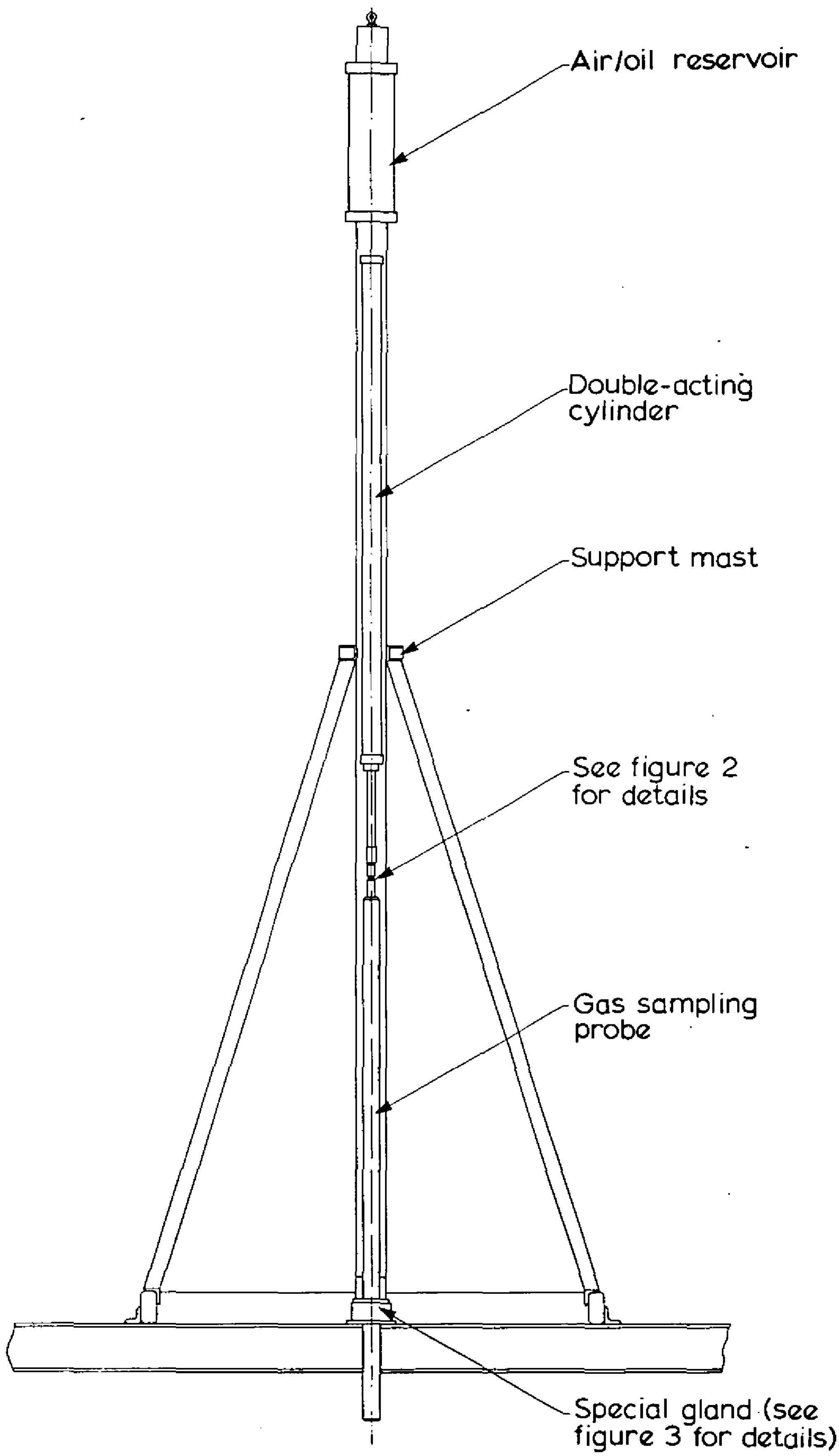

Figure 1a Gas sampling probe and mast on gas explosion chamber

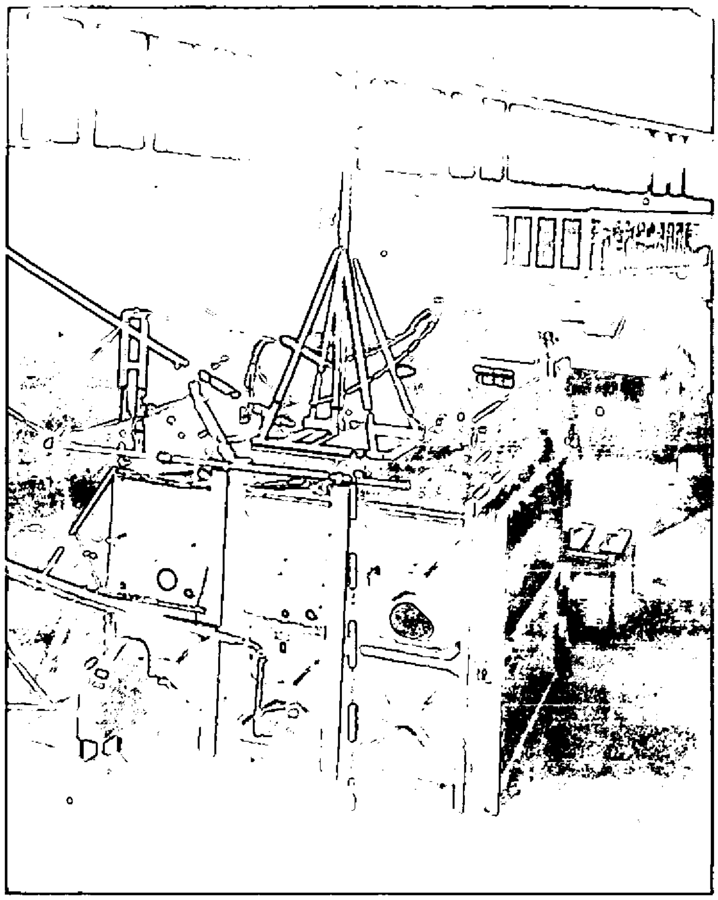

FIGURE 1b. GAS SAMPLING PROBE AND MAST ON GAS EXPLOSION CHAMBER

FIGURE 2. GAS SAMPLING PROBE SHOWING GLAND, GAS SAMPLING TUBE INLET, FLAME ARRESTORS AND VALVES

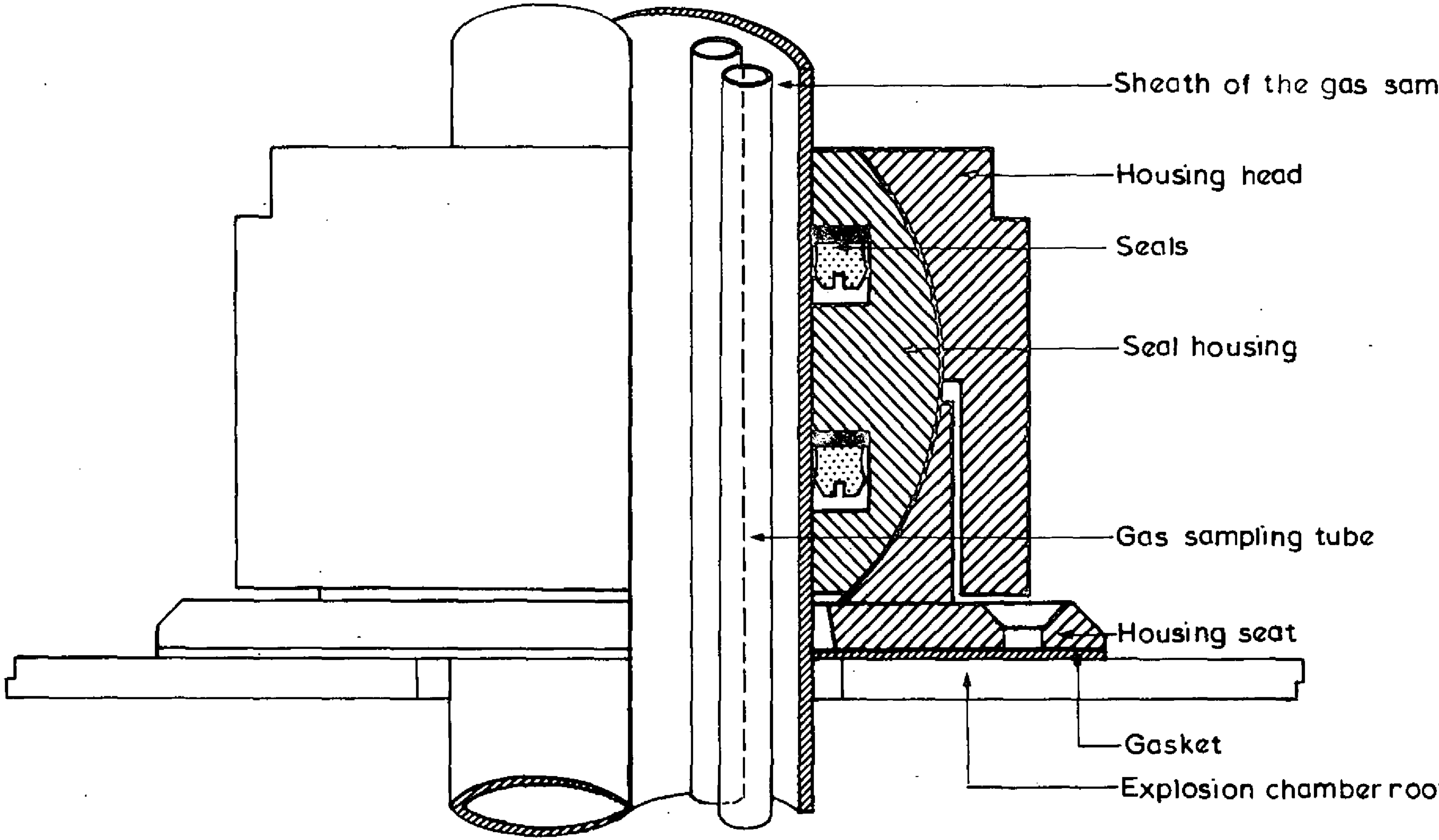

Figure 3 Part section showing the positions of the gas sampling probe and components of the gland, relative to the explosion chamber roof

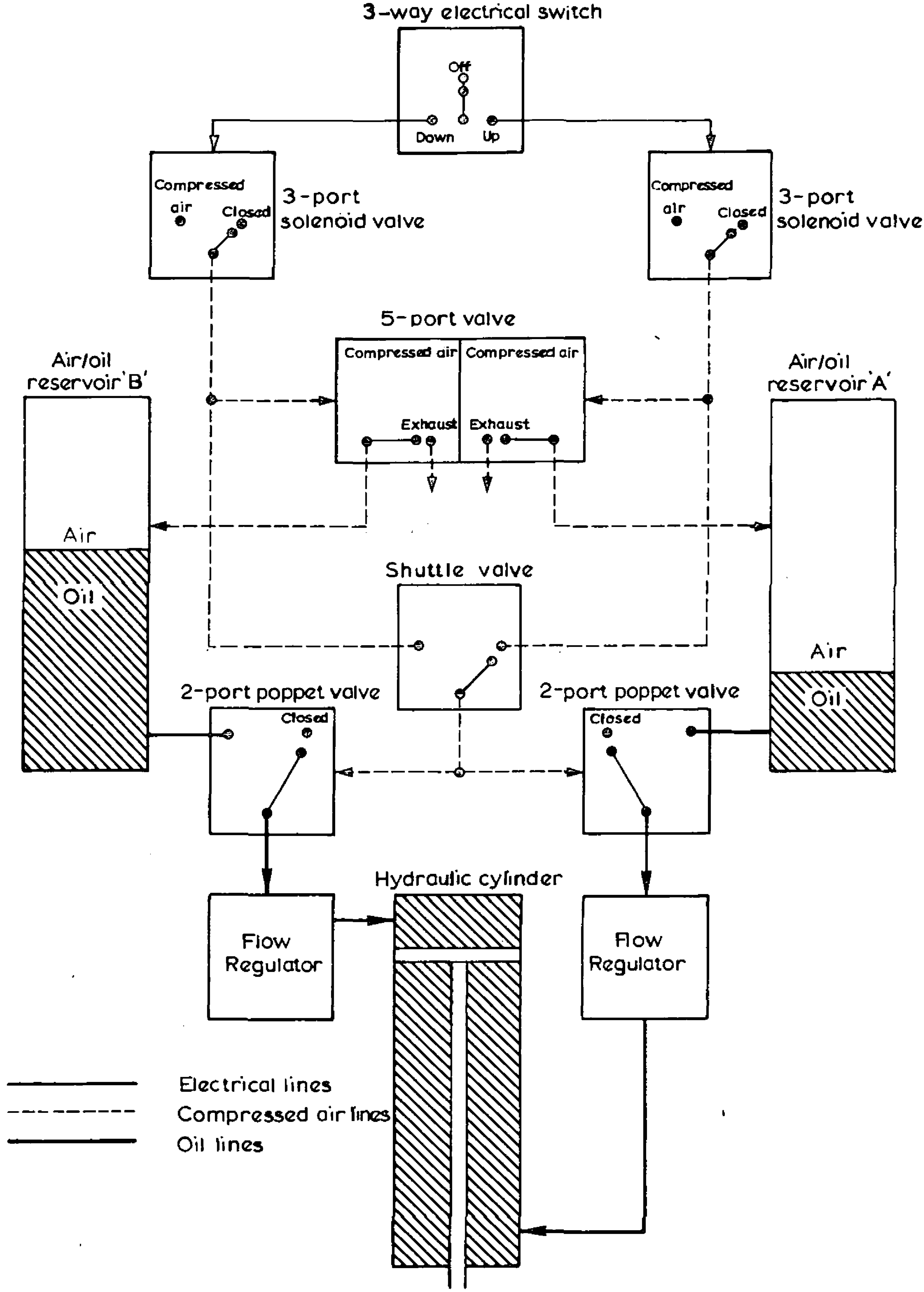

Figure 4 Diagrammatic representation of the hydraulic/pneumatic circuit for the gas sampling probe on the explosion chamber

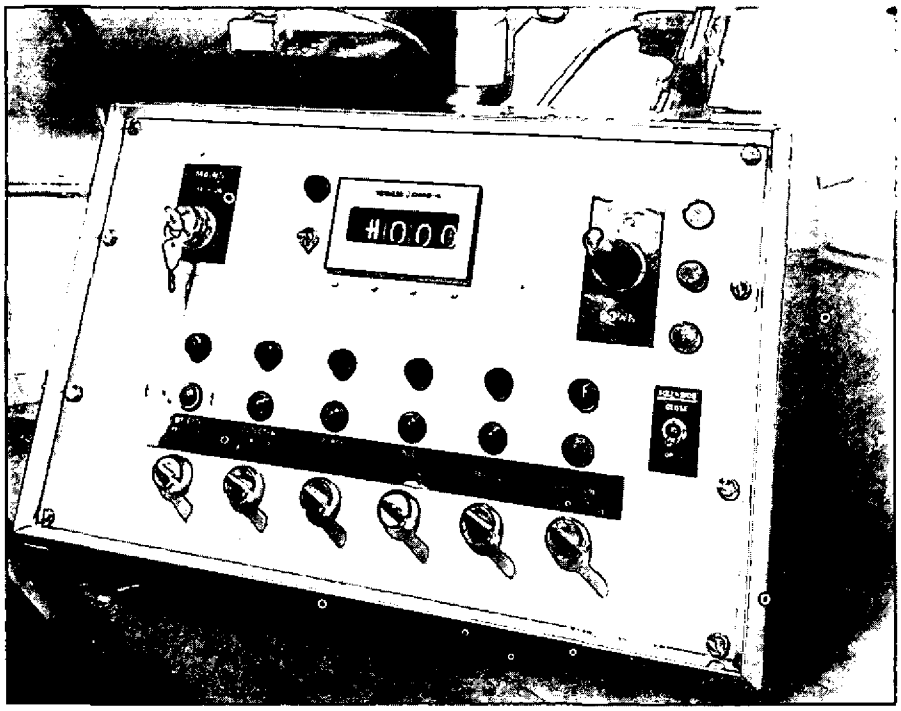

FIGURE 5. THE CONTROL PANEL

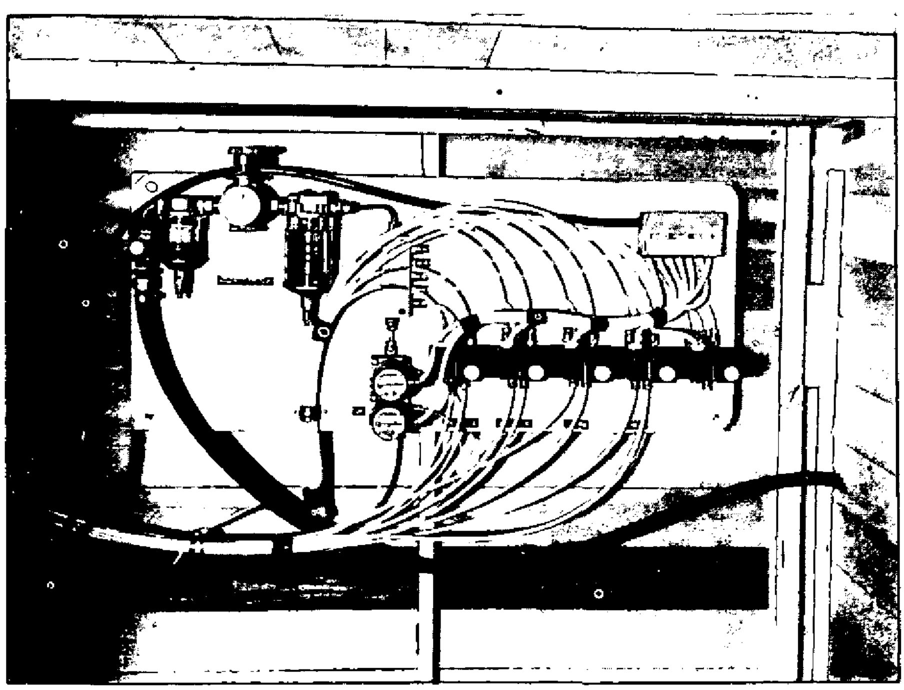

FIGURE 6. THE SOLENOID VALVES IN THE INTERMEDIATE OPERATING STATION

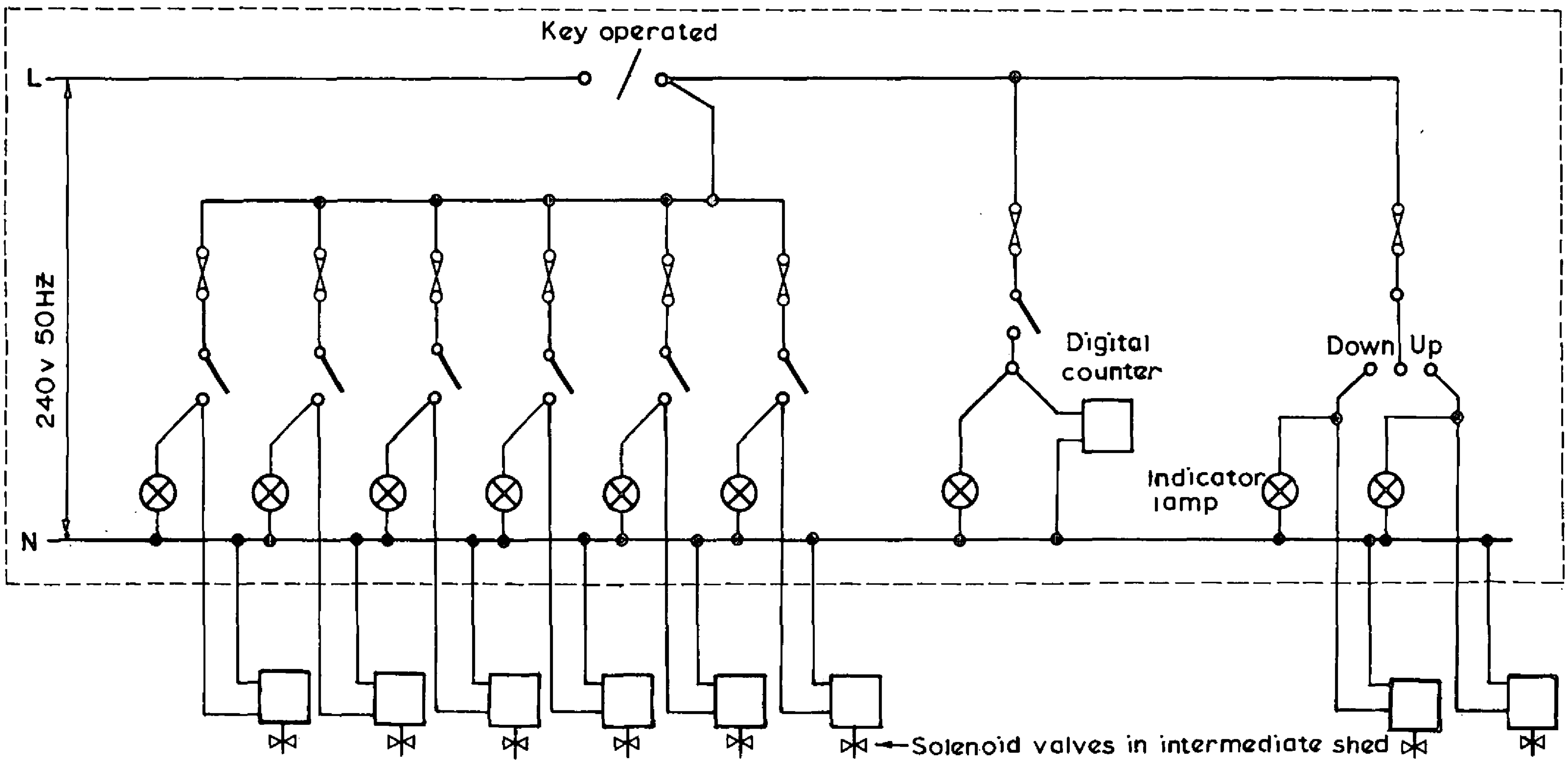

Figure 7 Electrical circuit of control panel

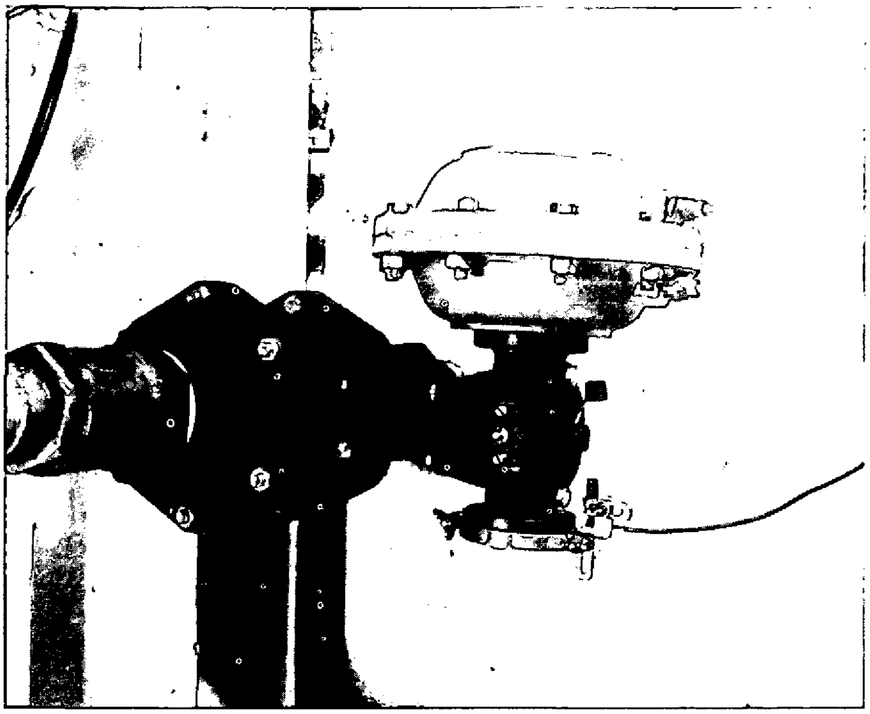

Figure 8 Pneumatic ball plug valve, showing mounted light activated switch

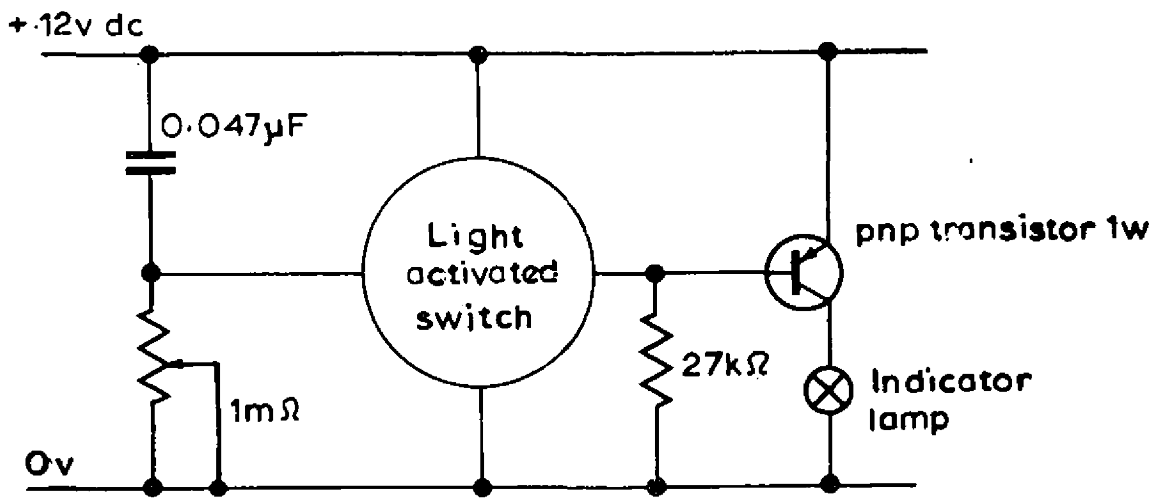

Figure 9 Electrical circuit of indicator system for pneumatic valve situation

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