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TECHNICAL MEMORANDUM NO. 12 OF 1963.

EFFECTS OF VARIOUS FACTORS ON THE
FLOATABILITY OF SMALL SAMPLES OF GREENSIDE COAL.

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EFFECTS OF VARIOUS FACTORS ON THE
NATURAL FLOATABILITY OF GREENSIDE COAL.

- (a) Influence of Specific Gravity.
- (b) Influence of different aeration gases.
- (c) Influence of adsorbed gases and vapours.

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THE INFLUENCE OF SPECIFIC GRAVITY ON THE
NATURAL FLOATABILITY OF GREENSIDE COAL.

The complete apparatus for testing small samples of coal is given in Figure 1. It consists of a 10 litre reservoir (1) which is kept filled with air (or any other gas if required) at a constant pressure by means of a tube (2), part of which is immersed in water (immersion 11 in.). The miniature glass flotation cell (3) is based on a design by Hallimond^{1,2}). It consists of a glass tube ca. 9 in. long and $\frac{3}{4}$ in. wide, with the closed end constricted and bent. Air from the reservoir can be admitted to the cell by means of a side tube (4) which is fused to the flotation tube as depicted in Figure 1. The portion of the side tube inside the flotation tube consists of a narrow-bore glass tube enabling bubbles of convenient size to rise along the upper side of the flotation tube.

During experiments coal particles are carried by the bubbles. On reaching the surface of the liquid inside the cell, the bubbles burst, releasing the particles which sink to the lower side of the flotation tube and slide down into the vertical side arm (5) consisting of a uniform measuring tube ca. 4 in. long and $\frac{1}{8}$ in. inside diameter.

The flow of air and consequently the rate of bubble evolution, can be controlled by the screw clip (6), while a rotameter (7) is introduced to indicate that a constant flow of gas is maintained throughout the experiments.

Greenside /

Greenside coal which had been stored under water, was ground under water in a mortar. The 60 - 120 B.S.S. mesh size fraction was separated into the following specific gravity fractions by means of zinc chloride solution:

S.G. Fractions: 1.40-1.42, 1.42-1.44 etc. to 1.58-1.60.

After each separation the desired fraction was washed thoroughly, first with tap water, and then with distilled water, after which it was stored under distilled water.

About 2 in. of distilled water was put into the flotation cell and air was bubbled through slowly. This was done to prevent coal particles from entering the side tube (4) when the coal sample was introduced into the cell. The detachable side arm (5) was filled with distilled water and connected to the cell by means of rubber tubing.

Approximately 0.5 g. of the 1.40-1.42 s.g. fraction of coal was placed in the water in the cell by means of a pipette after which the cell was filled with distilled water up to a specific mark near the top. The cell was placed in position (at an angle of 55°) with the aid of clamps. The gas flow was, thereupon, increased by opening screw clip (6) until the previously determined flow was obtained as indicated by the rotameter. The side arm (5) was tapped in order to get uniform packing of the coal particles which sank to the bottom of the tube. The length of the bed of collected particles was measured at five minute intervals as the test proceeded.

After 90 minutes the coal remaining inside the flotation tube was transferred to the side arm, during which process the latter was again tapped gently. The total length of coal was then measured. The percentage recovery was calculated from the individual lengths previously measured and the total length of the coal particles.

The experiment was repeated with other s.g. fractions.

Figure 2 represents percentage recovery with time for the various s.g. fractions. It is seen that the natural floatability of the coal decreases with increase of the specific gravity of the particles.

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INFLUENCE OF DIFFERENT AERATION GASES ON THE FLOATABILITY OF GREENSIDE COAL.

Slightly more than half a gram of 60 - 120 B.S.S. mesh size Greenside coal (s.g. 1.50 - 1.52), which had been stored under water, was dried under vacuum (See Figure 3) for two hours in a conventional drying pistol (1) at the temperature of boiling toluene. The sample was allowed to cool down to room temperature whereupon nitrogen was admitted at 2 to the system until atmospheric pressure was reached. The coal was left in an atmosphere of nitrogen overnight after which ca. half gram was transferred to a miniature glass flotation cell. The apparatus and flotation procedure was the same as that described on page 1.

Air, oxygen, nitrogen and carbon dioxide were used as aeration gases.

Figure 4 illustrates the percentage recovery against time, using the various aeration gases. It should be mentioned that, in all cases where dried samples were used, some coal particles floated on top of the liquid at the start of flotation experiments and it was difficult to get duplicate results. Recovery during the first ten minutes was found to vary a great deal. It is seen from Figure 4 that the slopes of the curves for air, nitrogen and oxygen are very similar after about ten minutes, while that for carbon dioxide is greater. It seems that better recovery is obtained by using carbon dioxide as aeration gas.

In a laboratory study of the effects of selected operating variables on continuous-cell flotation of coal, the U.S.B.M.³ reports that, using kerosene/pine oil as flotation agents for air-dried coal, substantially constant total recoveries were obtained using air, nitrogen, helium and natural gas for aeration. For an alcohol-type frother, larger variations were observed and they found that in this case reproducibility of results was poor. No mention is made of rate of flotation.

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The effect of carbon dioxide on the rate of flotation may be due to better adherence of the gas bubbles to the coal particles or to the change of pH of the water. When carbon dioxide was used as aeration gas the water in the flotation cell had been saturated previously with carbon dioxide (pH of solution 4.2). Allum and Whelan⁴ investigated the effect of varying the pH of the pulp of low rank coals on the yield, using a mixed oil (creosote, cresylic acid). In this study they found the optimum pH to lie between 6 and 10. Zimmerman⁵ found the highest coal recovery at a pH between 7 and 7.5. Gangrud⁶, by applying kerosene flotation on raw coal, found no noticeable difference in recoveries within pH range 5 to 9. As far as could be ascertained, the effect of pH on the rate of flotation was not mentioned by the above authors.

INFLUENCE /

INFLUENCE OF THE ADSORPTION OF VARIOUS GASES AND VAPOURS
ON THE NATURAL FLOATABILITY OF GREENSIDE COAL.

It is well known that the addition of so-called collectors and frothers during the flotation of coal improves the recovery. The collecting agent, clinging as droplets to the surface of the coal particles and being soluble and water repellent, attaches itself closely to the air bubbles. Frothing agents create bubbles capable of bearing particles denser than water to the surface without bursting to form a well-knitted froth.

It was decided to investigate the effect of the adsorption of various gases and vapours on the rate of flotation of Greenside coal.

The coal samples (60 - 120 B.S.S. mesh, s.g. 1.50 - 1.52) were dried in vacuum as was described previously (Figure 3.) The samples were allowed to cool down to room temperature and the various gases were let into the system until atmospheric pressure was obtained. Where liquids and phenol were used the vapours were adsorbed at pressures equal to the vapour pressures of the respective compounds. After 24 hours, tests were carried out on half gram samples of coal in the miniature flotation cell, using air as aeration gas.

The following gases were adsorbed:
carbon monoxide, carbon dioxide, oxygen, nitrogen, air, ammonia and a gas consisting mostly of propane and butane. No pronounced difference in the rate of flotation was observed. However, in the case of carbon dioxide the rate of flotation was somewhat higher than in the case of other gases.

When the flotation of samples of coal on which vapours had been adsorbed, was investigated it was found in some cases that the bubbles which evolved in the flotation cell were broken up into smaller bubbles. Duplicate tests showed the same phenomenon. This was observed with phenol, methyl isobutyl carbonol, cresylic acid, methyl amyl alcohol, oleic acid and pyridine. In all these cases the rate of flotation was much better than in the case of untreated samples. This must be due to the increase in the number of bubbles. The breaking up
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of the bubbles was irregular with the result that duplication of results was not very good.

No breaking up of bubbles was observed when samples of coal on which petroleum ether, benzene, toluene, xylene, paraffin and chloroform had been adsorbed, were treated in the flotation cell. The rate of flotation remained fairly constant and showed a slight increase over that of untreated coal. In practice these so-called collectors are added to the pulp in the form of liquids, and droplets of the liquid adhere to the coal particles, thereby improving the flotation as already mentioned. It is very doubtful that molecules adsorbed on the coal surface would improve the flotation. In one case it was found that benzene had condensed on the walls of the adsorption apparatus and therefore on the coal sample as well. When this sample was treated the rate of flotation was much higher than in the case where no condensation of benzene had taken place. See Table 1.

TABLE 1.

Rate of Flotation of Coal Samples where Condensation and no Condensation of Benzene had taken place.

Time (mins.)	Percentage Recovery with no Condensation of Benzene	Percentage Recovery with Condensation of Benzene
5	15	26
15	21	37
45	26	45
75	31	49
90	32	50

(SIGNED) P. C. DAVIS.

SENIOR TECHNICAL OFFICER.

PRETORIA.

29th. April, 1963.

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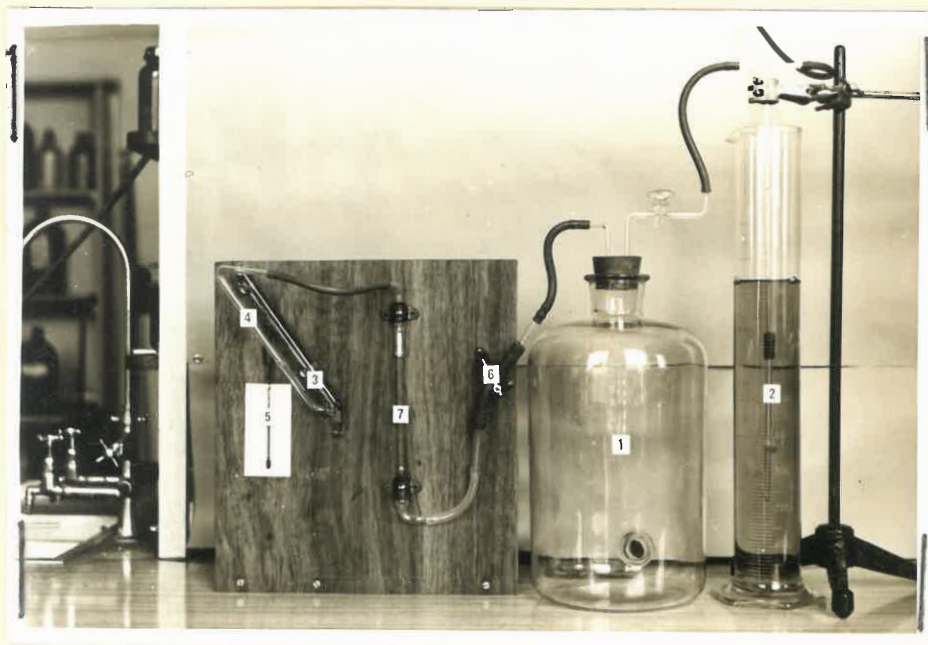
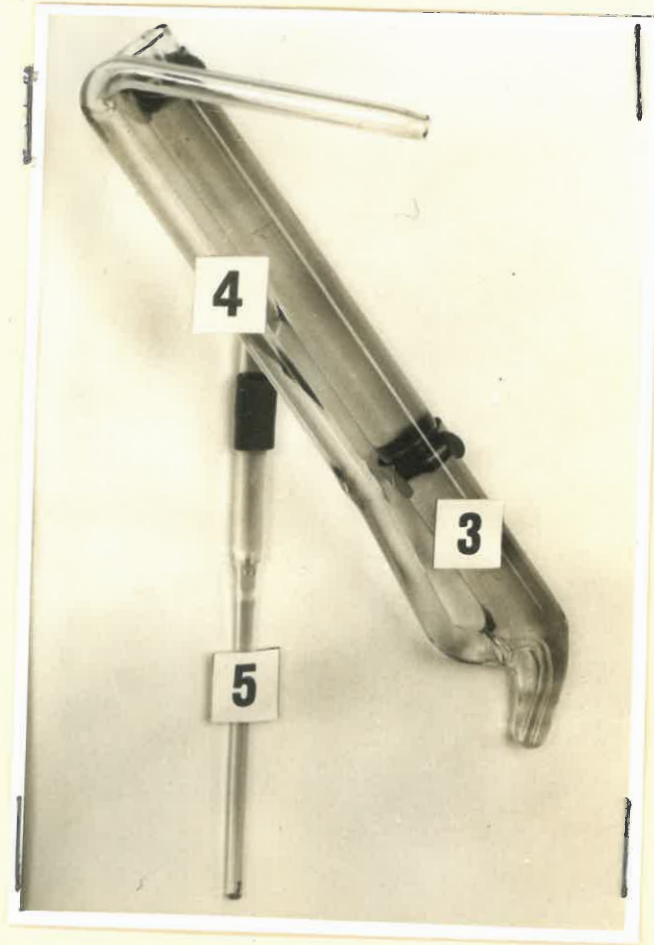


FIGURE 1.

Apparatus for Testing Small Samples
of Coal in a Miniature Flotation Cell.

FIG.4.

Effect of different Aeration Gases
on the Flotation of Vacuum-dried
Greenside Coal

- Air
- △ Carbon Dioxide
- Nitrogen
- Oxygen

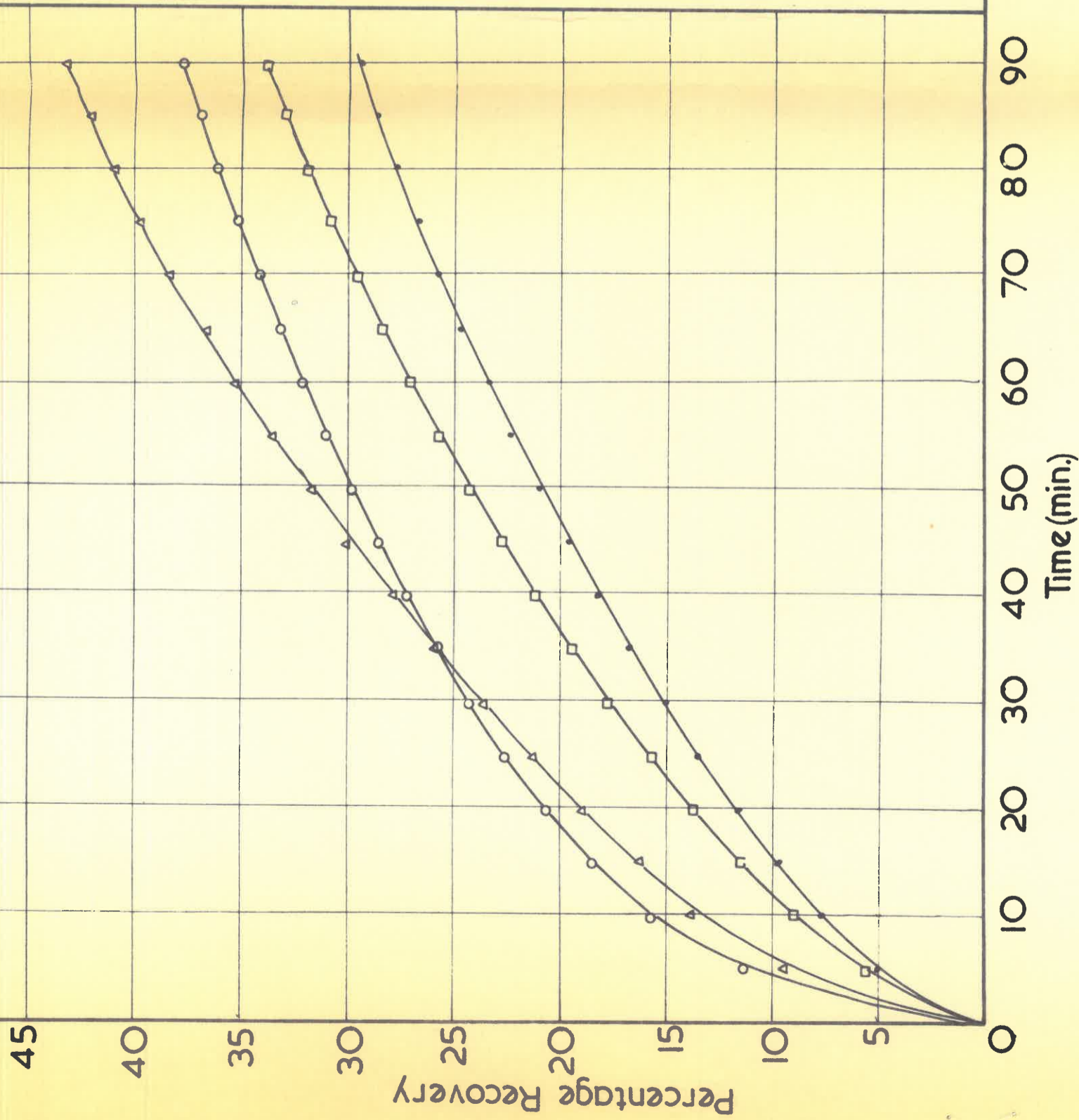
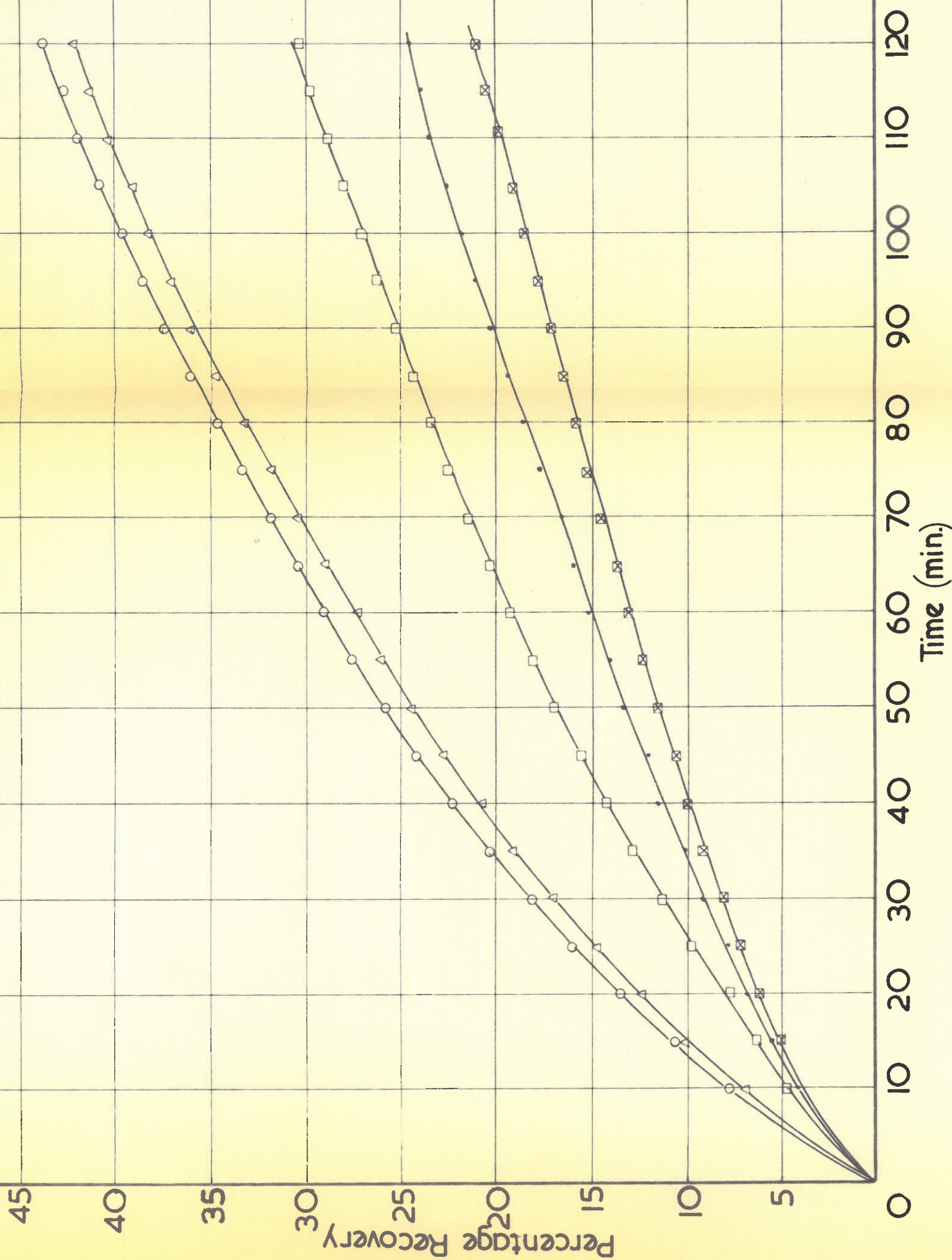


FIG. 2.

Rate of Flotation of
S.G. Fractions

- S.G. 140—142
- △—△ S.G. 144—146
- S.G. 150—152
- S.G. 154—156
- ⊠—⊠ S.G. 158—160



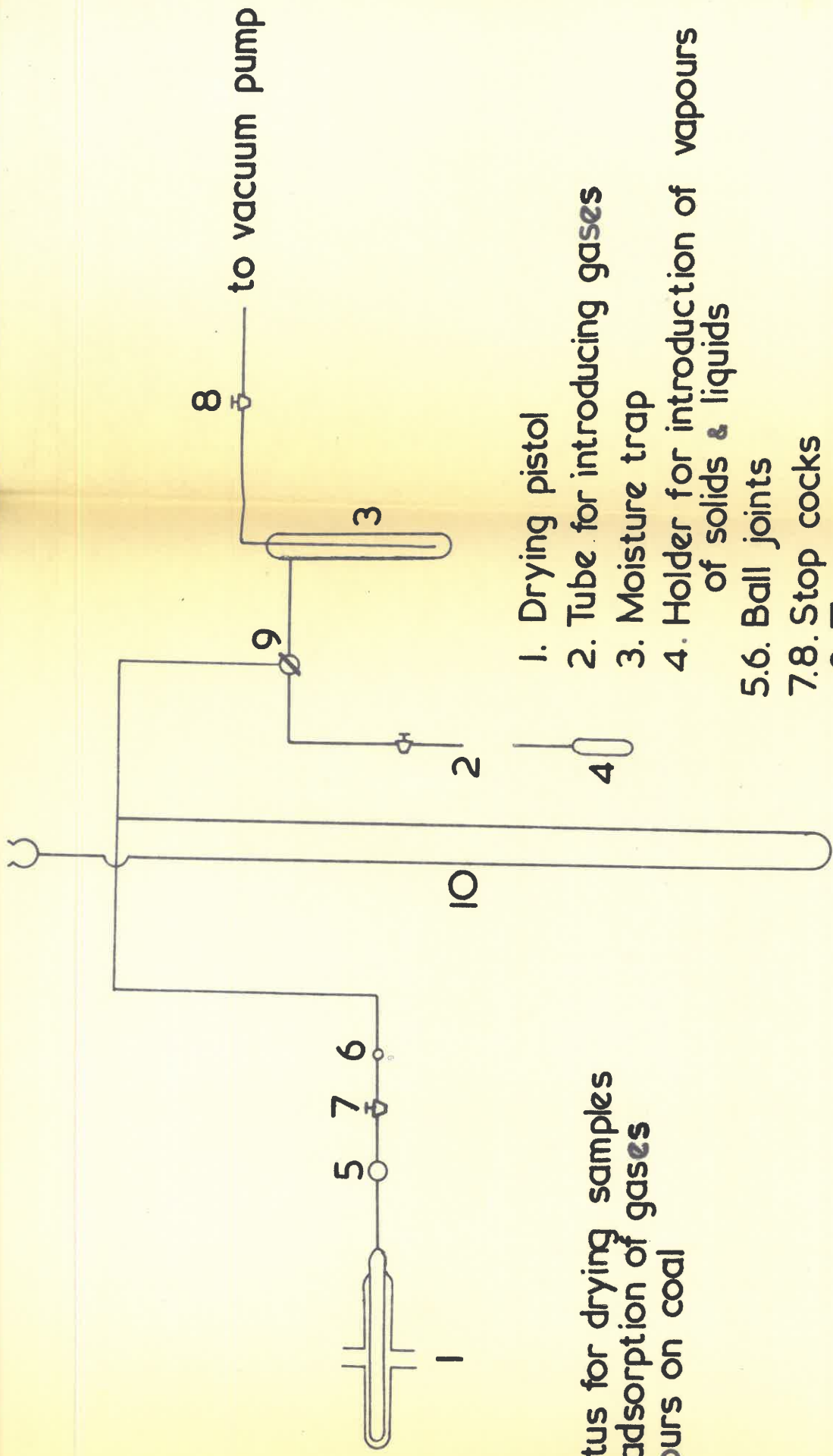


FIG.3
**Apparatus for drying samples
 & for adsorption of gases
 & vapours on coal**

1. Drying pistol
2. Tube for introducing gases
3. Moisture trap
4. Holder for introduction of vapours of solids & liquids
- 5.6. Ball joints
- 7.8. Stop cocks
- 9 Three-way stop cock
- 10 Mercury manometer