ISMA* Technical Meetings

Cambridge, United Kingdom
15-17 September 1953

**In 1982, the name of the International Superphosphate Manufacturers' Associations (ISMA) was changed to International Fertilizer Industry Association (IFA).*

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LE 406
TECHNICAL MEETINGS 1953
Paper (d) 3

September 1953

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CONVEYING, WEIGHING AND FEEDING GROUND PHOSPHATE FOR CONTINUOUS ADMIXTURE WITH ACIDS

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INTRODUCTION

The demand of Agriculture for superphosphate has lately necessitated the erection of new factories, and the enlarging of many existing ones. This demand, together with the desire on the part of manufacturers for a better product and the need to produce as cheaply as possible, has so encouraged technical development, that the call for modernisation is now constantly in our ears. Many unit process details are involved in our manufacturing methods, and accuracy in weighing, and precision in handling ground phosphate, are important examples.

FACTORY EXTENSIONS

On erecting a phosphoric acid plant at existing works at Barton-upon-Humber, the Farmers' Company had to increase their phosphate grinding capacity, and instal a ground phosphate conveying system within the limits of existing buildings. In order to conduct full scale experimental work with the minimum of interference with normal production the acidulating plant (Broadfield) was much modified at the same time, to give operational flexibility over a wide range of conditions, and den capacities.

NEED FOR WEIGHING GROUND PHOSPHATE

Rock phosphate ground to ordinary requirements for superphosphate manufacture, even in a single mill, will suffer segregation of particle sizes at times, because of the movements in the storage hoppers of the type of circulatory system employed here. See Fig.1. From time to time this segregation creates considerable differences in the apparent density of the ground phosphate in circulation. It was, however, the intention to have a controllable flow of ground phosphate with widely varying degrees of sub-division, and particle size distribution, on tap as it were, so the installation of a second grinding mill was indicated from the first, in preference to replacing the existing mill; so it was that different types of mills came to be paired, and a method of weighing the phosphate became essential if accuracy of apportioning was to be attained.

This paper is therefore, in effect, a report on the alterations and additions, privately undertaken and only recently completed. Comparison with weighing methods already in use is not intended.

CONVEYING AND WEIGHING SYSTEMS

Fig.2 illustrates the layout of the plant on completion, the whole having been planned in relation to the originally existing No.I Mill and No.2 Hopper.

Phosphate from either of the mills can be stored in any of the three hoppers, there to be held available for any of the main end uses - the manufacture of superphosphate, triplesuperphosphate, and phosphoric acid.

Orthodox types of automatic weighers were installed, with the weighments electrically discharged. The weighed phosphate is discharged into a variable speed spiral conveyor which provides a means for regulating the continuous flow of phosphate to the mixer.

BULK PHOSPHATE

It has been found that the bulk phosphate being handled can vary in apparent density from 0.8 when aerated to 1.5 when packed.

In normal practice the variations lie within narrower limits, approximately between 0.95 and 1.3.

These screening tests show, in random samples, the nature of the comminution towards each end of the size range.

B.S.S. Sieve Number	Aperture Microns	Mesh Sizing	(1) Phosphate ex Bradley Mill.	(2) Phosphate ex Sturtevant Mill
100	150	+ 100	2%	18%
200	76	- 100 + 200	25%	41%
240	66	- 200 + 240	18%	12%
300	53	- 240 + 300	27%	14%
-	-	- 300	28%	15%

The apparent density of sample(1)can be varied between 0.84 and 1.3 and of sample (2)from 1.02 to 1.44.

The angles of repose of these phosphates, vary roughly between 20° and 30° in a normal 'storage system' state, and when aerated, from 0° to 7°.

ELECTRICITY SUPPLY

In Britain, the normal voltage of the public electricity supply is subject to a permitted statutory variation of ± 6%. In recent years irregular fluctuations have been frequent because of a policy of load shedding at times of peak demand, made necessary by the shortage of generating plant on the national system.

With an A.C. electricity supply which is liable to vary between say 415 V. and 380 V., and motorised drives operating under normal load conditions, changes in motor speeds amount approximately to reductions of 60 r.p.m. on 2,000 r.p.m., and 30 r.p.m. on 700 r.p.m.; a possible variation from this one cause of from 3 to 4 per cent.

Any piece of machinery, like the spiral conveyor referred to, which is dependent on timing for accuracy, can be protected against such irregularities, if indeed a closer degree of accuracy is required. In this respect the constant speed podiometer conveyor belt, and the mechanical variable speed unit, both electrically driven, come readily to mind.

ELECTRONIC MOTOR CONTROL

An electronic motor control as shown diagramatically in Fig.4, maintains a constant motor speed despite fluctuations in mains voltage, and working loads.

The degree of accuracy is ± 0.1%

Such a system also gives protection against motor stall conditions since the armature current will rise to the pre-set value only, which is the maximum motor current.

The single phase alternating current employed is rectified by thyratron valves, the direct current being fed to a shunt wound geared motor.

A potentiometer control enables the output speed to be varied, the drive in this particular case being to the variable speed spiral conveyor.

A tachometer generator is directly coupled to the non-driving end of the motor armature shaft (Fig.2 top left.) The voltage generated here is used to correct changes in motor speed due to any irregularities along the drive. The time taken to do this is less than one tenth of a second.

Voltage generated by the tachometer is proportional to its speed, and is balanced against a stable voltage appearing at the main speed potentiometer. When a difference occurs between these two voltages correction is automatic and the motor speed is maintained at the correct level.

VARIABLE SPEED SPIRAL CONVEYOR.

The spiral conveyor used to convey and regulate the flow of phosphate from the weigher reception hopper to the mixers is 12 ft. long.

Variations in speed are obtained by control of the motor armature voltage, a reduction down to one twentieth of the motor base speed being practicable, although in this instance 10% was preferred.

The speed of the conveyor is infinitely variable between 10 and 100 r.p.m. A visual speed indicator is provided.

With this fine control, it is the work of a few minutes only to set the speed so that the weighed batches of phosphate (maximum 170 lbs), are smoothed out, and conveyed to the mixer in a steady flow.

The pitch of the spiral is normal, except for the first two feet directly below the reception hopper, which is of 2" pitch.

At 100 r.p.m. a 4" diam. spiral of this type has a capacity of 79 c.ft. per hour, and a 6" spiral 265 c.ft. per hour.

With the volume of a ton of ground phosphate varying from 38 c.ft. to 28 c.ft., it is seen how the tonnage capacities of the conveyors change.

This serves to emphasise our need for true weight, and the unreliability of volumetric measurement.

AUTOMATIC PHOSPHATE WEIGHER

The weigher is of an even arm beam type, and it should be emphasised that some details of construction were of an experimental nature.

With an empty weigh bucket the weight box sinks and tilts the beam so that the feedgate opens and the bucket fills. When the required weight is obtained the feedgate closes.

The bucket door normally opens automatically, but in this case the action is suspended until released by the functioning of a solenoid which is electronically controlled.

A sliding weight is fitted to balance, after trial, the phosphate in mid air, between the feedgate and the bucket, at the moment of balance.

A weighing accuracy of $\pm \frac{1}{4}$ of 1 per cent is obtained with tipping periods of 40 seconds and over.

If high speed weighing operations are necessary, say within the time range from two to four discharges per minute, the degree of accuracy can be expected to drop to ±1 per cent.

The weigher is enclosed in a vented cubicle which affords a means of controlling the occasional puffs of light dust which emanate from the machine. It also protects the working mechanisms from corrosion by chemical fertiliser dusts, and acid fumes which may arise from nearby plant.

ELECTRONIC WEIGHER DISCHARGE CONTROL

The weigher discharge trip is released by a solenoid periodically energised by a two-interval electronic timer (Fig.5).

In the timer, alternating current is rectified and electronically regulated. The controlled D.C. voltage thus obtained is fed to a first interval timing valve through a potentiometer, and at the selected interval current is passed to the solenoid.

The current is maintained for a short time by the action of the second valve, five seconds in this case, when the timing cycle restarts.

Two units are in use, one with a range of 40 to 400 secs., the other 72 to 720 secs..

REMAINING SOURCES OF POSSIBLE INACCURACY

If the weigher is allowed to become sluggish in action, for need of cleaning, or by excessive wear, it is possible for the solenoid to operate, and yet for the bucket door to remain closed.

When the weigh bucket opens it is essential that it completely empties itself each time.

From the opening to the closing of the weigher bucket door, approximately the time taken for the phosphate to gravitate to the reception hopper, the interval is 3 secs..

A glass window in the hopper enables the operator to see that the weighment is discharged at the set period, but only a check weight test can show that the discharge is complete.

It is of course equally important that the feedgate closes properly when the required weight is obtained. Attention must be paid to this as the gate can be fouled by foreign matter.

Check tests are made by weighing samples drawn from the variable speed spiral conveyor when the circulatory systems shown in Fig. 6 are in motion.

MAINTENANCE AND PERFORMANCE

A few figures concerning maintenance work done will be of interest to readers.

The figures relate to the first 2,000 hours of actual production time on the Broadfield Acidulating Unit, after the fitting of the weigher and its accessories, when operators and maintenance men alike, were making themselves familiar with their use.

On the electronic control panels, organised maintenance, on the average, was 1 hour for every 60 hours run, and on the weigher, 3 hours for every 120 hours run, one man being employed in each case.

Individual unbudgeted for stoppages, varying from between 1 hour and 4 hours each, amounted to 11 hours on weigher repairs, 19 hours cleaning and easing the weigher mechanisms and 6 hours adjusting, repairing, or cleaning the electronic controls, a total of 36 hours which is the equivalent of one hour lost for each $55\frac{1}{2}$ hours run - an operating efficiency of 98.2%.

It is confidently expected that with the experience gained greater efficiency will be readily achieved in the future.

Loss of working time due to sluggish weigher action is now negligible.

AIR FLOW CONVEYOR

The main conveyor in the system is 135 ft. long and of airflow construction, a section of which is shown in Fig. 3.

The upper and conveying trough is separated from the lower air trough by a continuous length of porous material of restricted air permeability.

The air pressure to be applied to the lower trough is naturally dependent upon the combined resistance of this porous material and of the phosphate layer, which, in this case, is of such an order, that with the air pressure at 9" w.g., the air flow is $4\frac{1}{4}$ cub.ft./sq.ft./min.. At this figure the ground phosphate is fluidised to the required degree and there is a ready gravitational flow of phosphate in the upper trough, when the conveyor is inclined at $2\frac{1}{2}^{\circ}$ from the horizontal.

With 45 sq.ft. of porous medium the total air used is 191 cu.ft./min. The small fan used consumes 0.8 B.H.P.

The upper trough is vented through filters to prevent a build up of air pressure in the adjacent plant, and to restrict the velocity of air in the trough itself.

The conveyor performs the duties of handling phosphate from the two mills, at one and the same time, or individually, as a spiral conveyor would.

The only moving part is the fan.

The troughs are conveniently bent to suit the layout.

Operation is dustless.

The maximum load demand on this 4" wide conveyor is about 7 tons/hr; the actual maximum capacity is nearer 20 tons/hr of the 'lightest' of the phosphates.

PROCESS ADJUSTMENTS AND EXPERIMENTS

The periodic adjustments in the proportions of phosphate and acid required because of changes in chemical composition, are readily affected at the weigher.

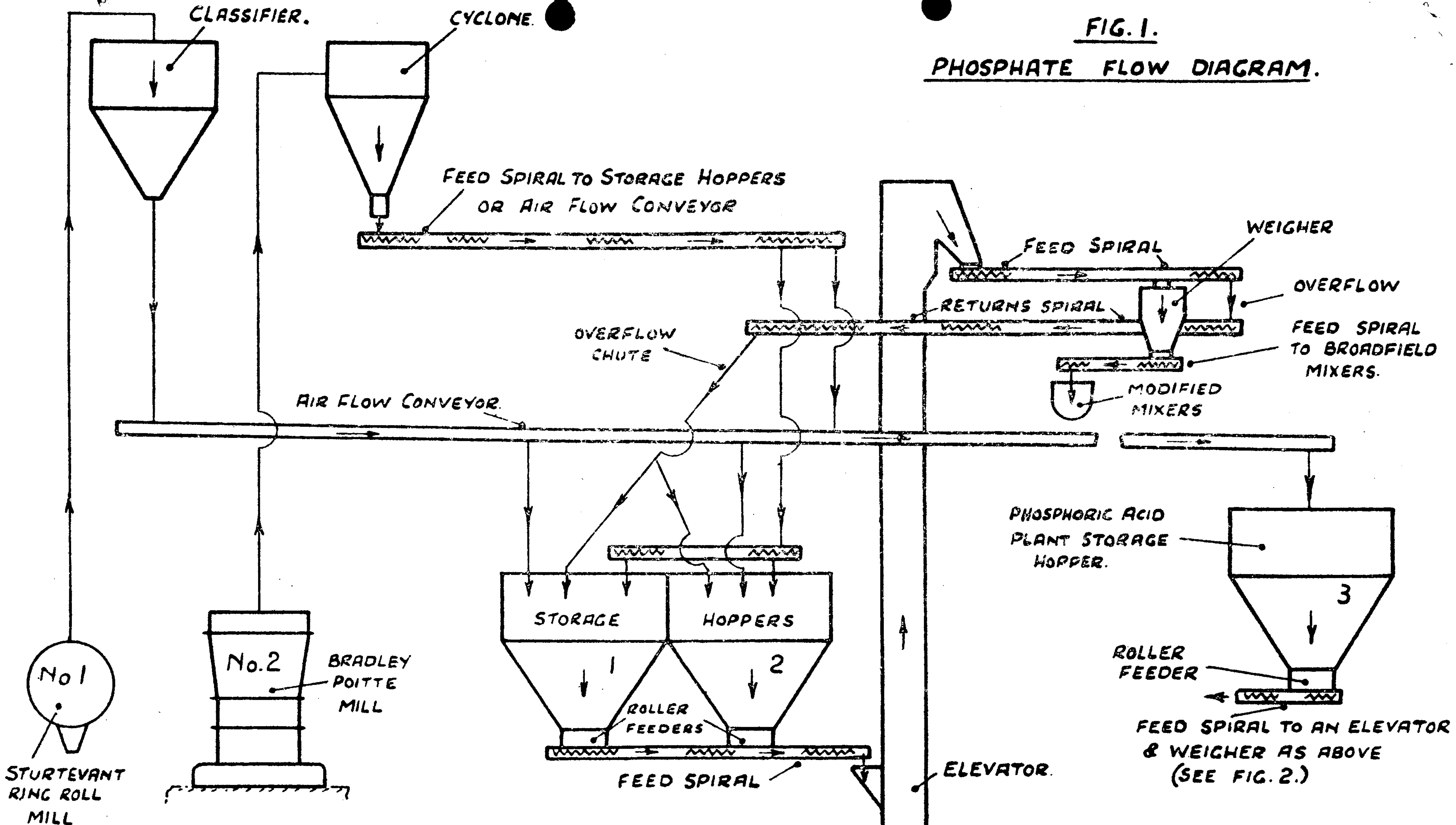
This ease and surety of control also facilitates the change over from one manufacturing process to another.

Whenever possible for experimental work, the weigher trip mechanism control is set to operate a complete cycle in 60 seconds.

Apart from simplifying the weight calculations, as the electro magnetic counter is then recording minutes, a ready check is available on the time of the run, as the controller achieves a high degree of accuracy in time keeping.

FIG. 1.

PHOSPHATE FLOW DIAGRAM.



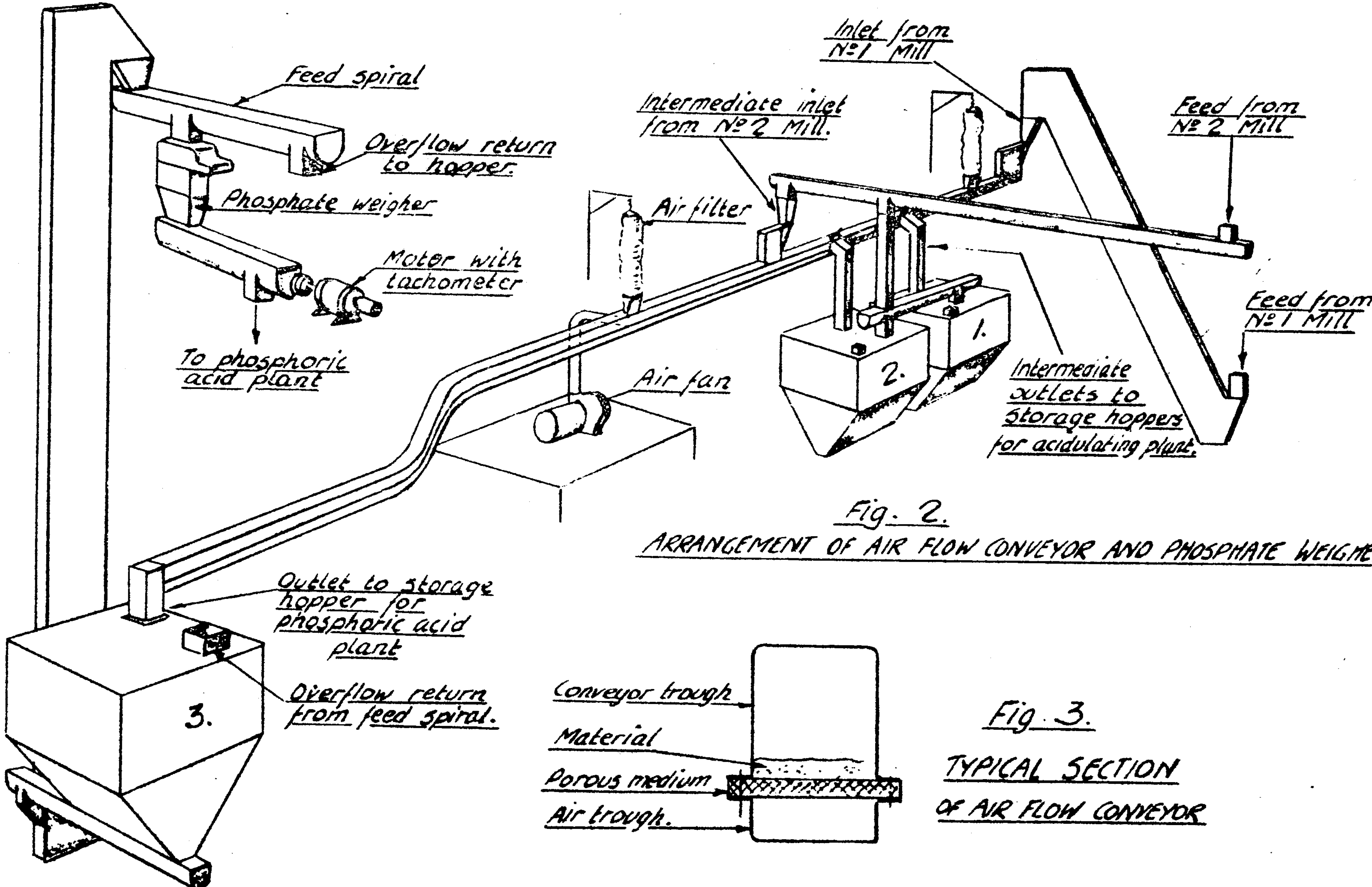


Fig. 2.

ARRANGEMENT OF AIR FLOW CONVEYOR AND PHOSPHATE WEIGHER.

Fig. 3.

TYPICAL SECTION OF AIR FLOW CONVEYOR

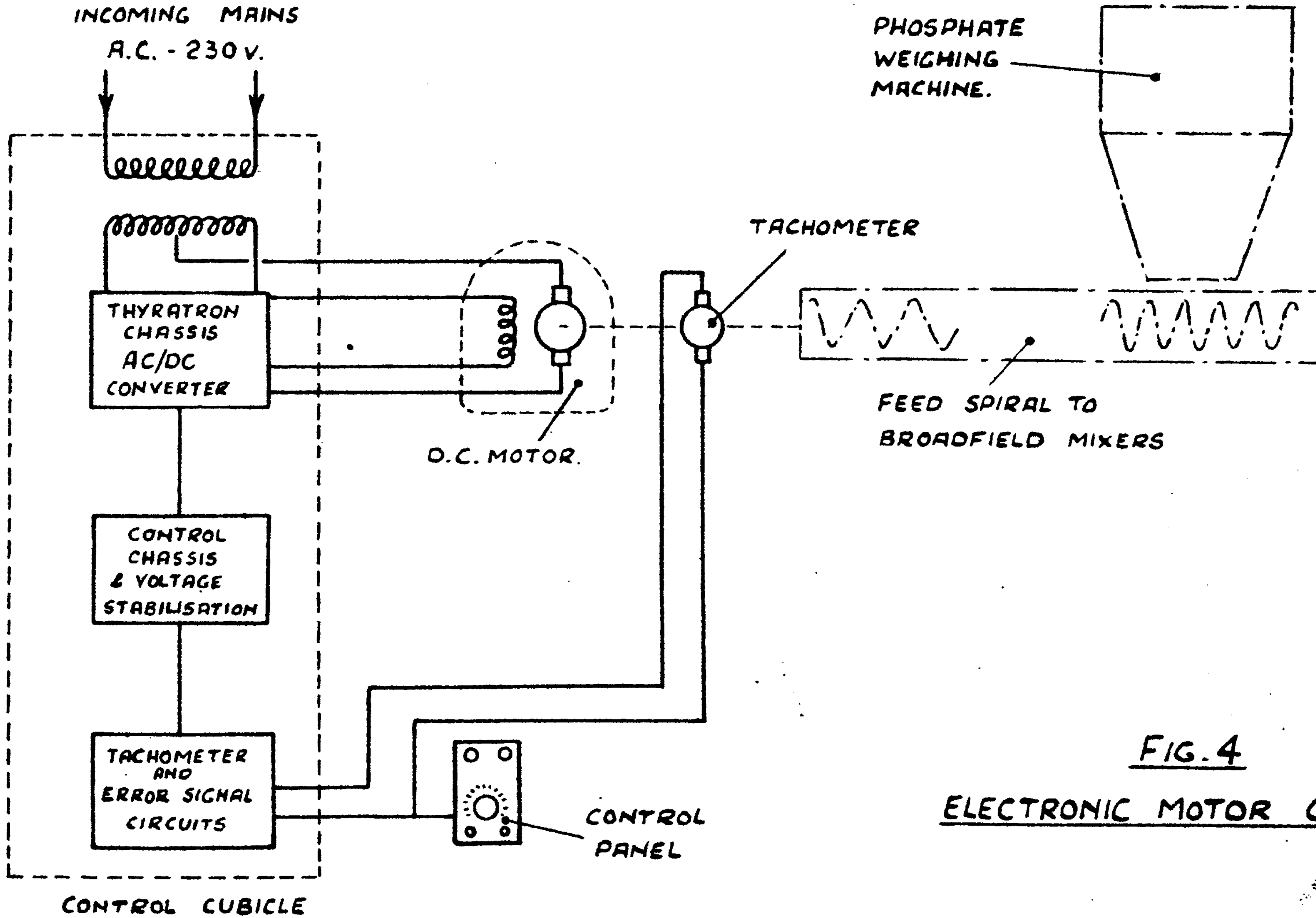


FIG. 4

ELECTRONIC MOTOR CONTROL.

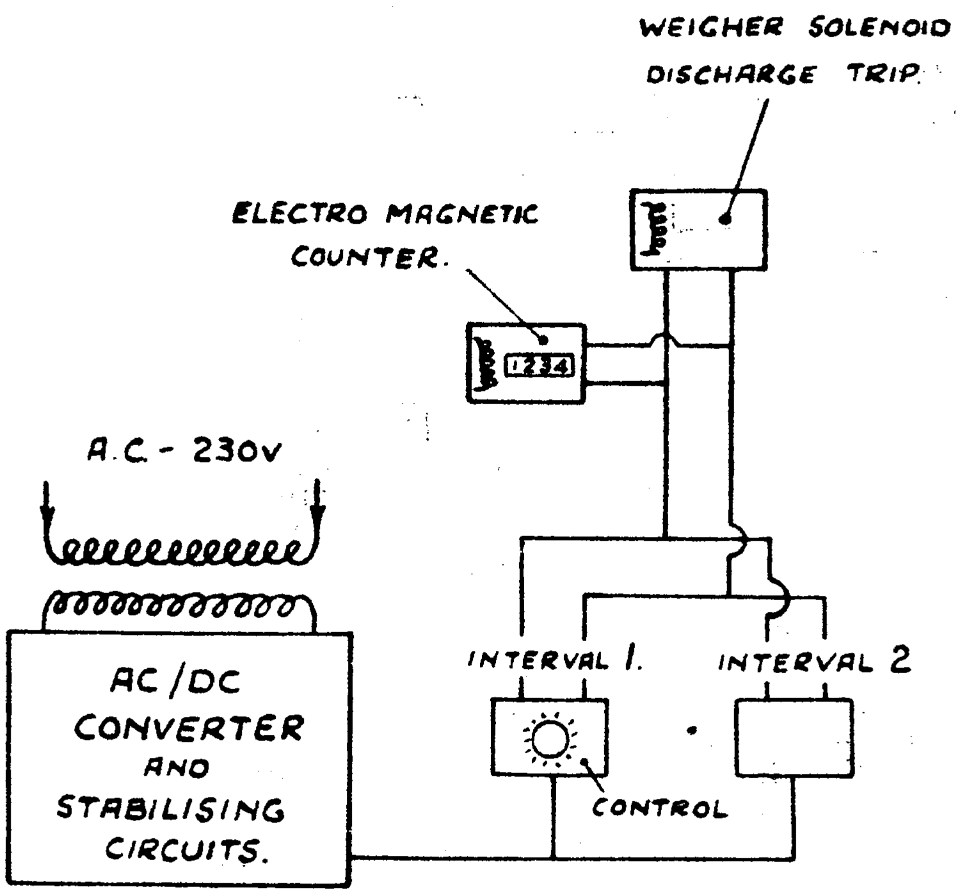


FIG 5

TWO INTERVAL
ELECTRONIC WEIGHER DISCHARGE
CONTROL.

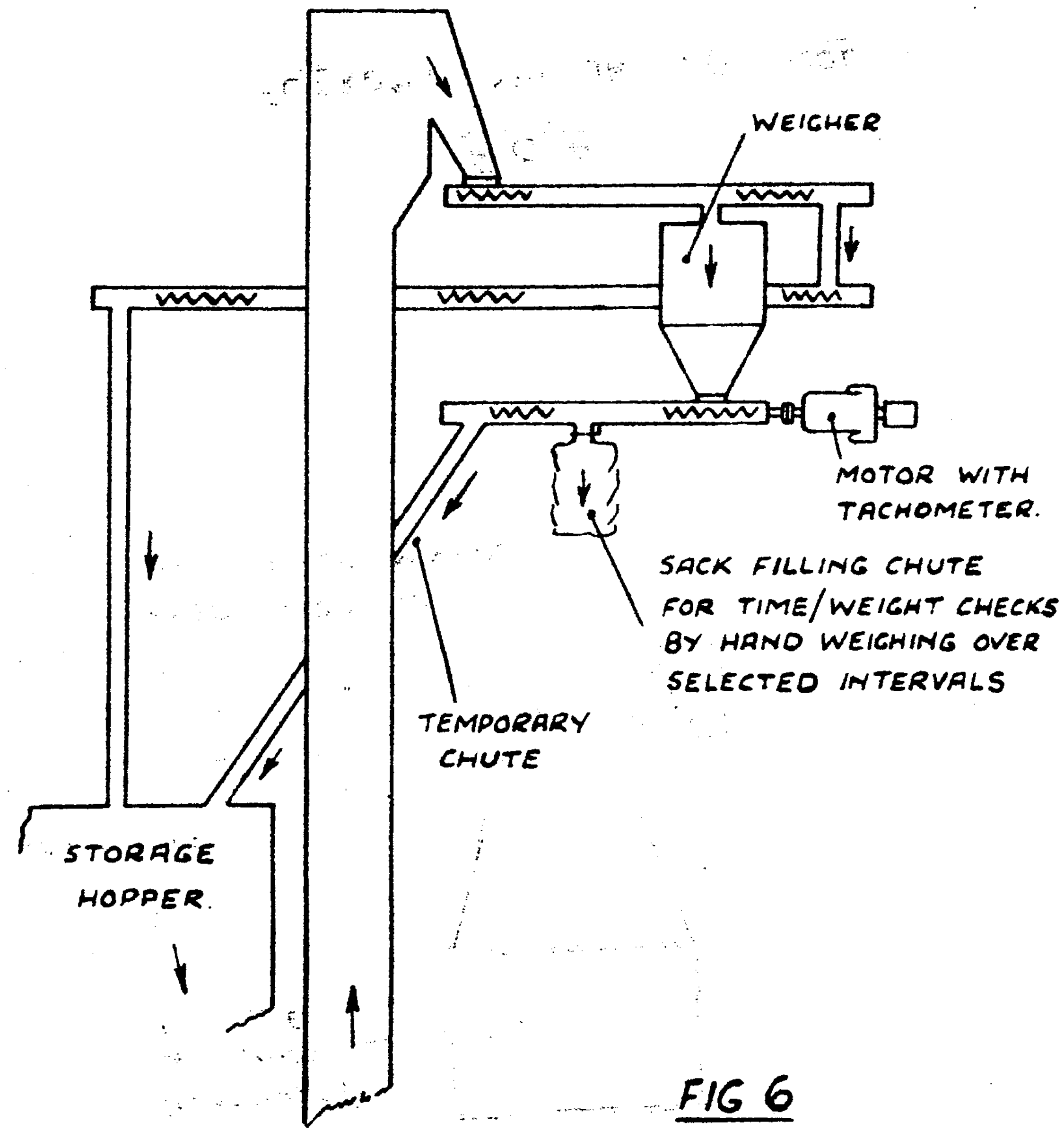


FIG 6

CHECK WEIGHING ARRANGEMENT.