

also arranged to use with this lens, just before second contact, an objective prism forming a spectrum upon a plate moved each second by clockwork and thus suited to catch the "flash spectrum," so called. This necessitated a second tube 135 feet long inclined at about 8 degrees to that used for the direct photographs of the corona. Both tubes were made of thick Canton flannel and were 42 inches square with diaphragms of progressively increasing size 10 feet apart. The two tubes were fastened to trestle work covered by long canvas tents. Nearly one thousand yards of canvas and flannel were thus made up. The tube ended in a small photographic house which had been prepared in sections and was transported from Washington to Sumatra. Besides the great horizontal telescope a 5-inch, 38-foot lens was also used for obtaining inner coronal photographs. This lens was mounted upon a pole in such a manner as to be in line with the sun from the eastern window of the photographic house at the moment of totality. A conical tube of white canvas, well blackened within and 36 inches square at its lower end, ran from the house to the lens, but was not attached to the lens or its housing. There being thus no provision for following the apparent motion of the sun with the lens, a suitable motion was given to the photographic plates by means of a clock. With this instrument 11 by 14-inch plates were employed. Upon an instrument which carried the 18-inch mirror of the horizontal telescope was mounted equatorially a 6-inch photographic lens of 7½-inch focus, provided with a conical tube, so that a considerable field was covered. A shade glass, opaque to violet light, was placed over this lens. The purpose of the shade glass was to enable a comparison to be made between the form of the outer corona as photographed with yellow and green light and as photographed with the complete coronal radiations by other lenses.

Within the eastern part of the shed there was mounted upon an improvised polar axis a collection of four cameras well provided as to moving gear by being connected with the very accurate spectro-barometer clock. These cameras were two similar pairs, one with short focus and the other with long focus lenses. The former were two landscape lenses of 4½ inches aperture and 40 inches focus, each provided with a 30-inch square plate. In front of one lens was placed a shade glass opaque to violet light. The two long-focus lenses were of 3 inches aperture of 111 feet focus and resembled those recommended by Harvard College Observatory as most suitable for photographic research for a possible intramercular planet. The axes of these two cameras were inclined so that together they covered a space east and west of the sun about 12 degrees by 28 degrees in extent. Their fields were found to be so nearly flat as to permit the use of a single plate 24 by 30 inches.

THE UTILITY OF ALKALINE PHOSPHATIC MANURES.

By JOHN HUGHES, F.I.C.

BEFORE considering the subject included under the title of this paper, it will be desirable to briefly refer to the origin and progressive use of

ACID PHOSPHATIC MANURES.

The manufacture of superphosphate in this country may be said to have commenced in 1842, when the late Sir John Bennett Lawes, F.R.S., obtained a patent for treating finely-ground mineral phosphates, such as Cambridge coprolites, with commercial sulphuric acid. The chemical theory then put forth maintained that the agricultural value of phosphatic manures depended upon the extent to which the phosphates they contained were rendered soluble in water through the aid of acid. It was contended that this solubility in water effected the most complete diffusion through the soil that could possibly be obtained, and the theory in itself is still correct, though its application should be restricted to soils containing plenty of lime, so that the acidity of the manure may be immediately absorbed by alkali in the soil. Indeed, at first, sulphuric acid being expensive, it was only used in small proportion, and great caution was observed in the mixing arrangements. Only a portion of the phosphates in the coprolites was rendered soluble in water, amounting perhaps to 20 per cent in the manure produced, and frequently as much as 8 to 10 per cent was left in the form of insoluble or undissolved phosphate of lime. Consequently, in those days, superphosphate was sent out in an excellent dry condition, and this in itself contributed very materially to increase the sale and render the new manure popular among farmers, for there were never any complaints about the damp acid condition of the manure.

When acid, however, became cheaper as the result of improved manufacture from less costly materials, and as competition increased on the expiration of the original patent rights, sulphuric acid was added in greater quantity, and the utmost possible amount of soluble phosphate was obtained, so that only 2 or 3 per cent of phosphate of lime was left in a condition insoluble in water.

Superphosphate then became damper and more acid, so that complaints respecting its bad condition were of frequent occurrence.

Superphosphate when first introduced was chiefly applied as a manure for turnips and swedes raised on good arable land containing sufficient lime, yet there appears to have been some doubt raised in the mind of so keen an observer and experimentalist as the late Dr. Augustus Voelcker, F.R.S., as to whether acid manures were not conducive to disease in these roots.

At any rate, as early as 1863 we find him writing in the Journal of the Royal Agricultural Society upon "Phosphatic Manures for Root Crops" as follows:

"Superphosphate of lime applied to root crops has a different practical effect on different soils.

"Purely mineral superphosphates fail to produce good turnip crops on light sandy soils.

"It has indeed been observed that the exclusive use of superphosphate, however beneficial it may be in the majority of instances, has in some soils led to the complete or partial failure or the presence of disease in the turnip crop.

"No acid combination as such can enter into plants

without doing them serious damage; even free vegetable acids, as humic and ulmic acids, are injurious to all crops cultivated for food for the use of man or beast; and unless these acids, which are always present in what practical men call sour humus, are neutralized by lime, or marl, or earth, none but the roughest and most innutritious herbage can be grown.

"Free mineral acids are, I believe, still more injurious to all farm crops, and perhaps to all plants, than the free organic acids that are found in humus.

"A very dilute solution of sulphuric acid—say one part in 1,000 of water—may be used with advantage for killing grass in gravel walks made with flint or quartz sand; after one or two applications, the weeds will be destroyed and will not reappear for a long time. But if the walks are made with limestone gravel, the application of a much stronger acid has little or no effect on the grass or weeds; after some time the latter seem to grow all the better for having had a taste of dilute sulphuric acid. In reality, however, no acid enters these plants, but on coming into contact with the limestone gravel unites with the lime to form that useful fertilizer, sulphate of lime or gypsum.

"These examples thus prove unmistakably that a soil which contains free acid, in ever so small a quantity, is unfit to maintain a healthy growth.

"We have, therefore, strong presumptive evidence that soluble phosphate, a combination which has a strongly acid character, does not as such enter the roots of plants.

"The reconversion of soluble into insoluble phosphate, perhaps may appear undesirable, but in reality, it is not only beneficial, but absolutely necessary to the healthy and luxuriant development both of turnips and all other crops to which superphosphate is applied.

"The more rapidly and completely the soluble phosphate in commercial superphosphates and turnip manures, is precipitated and rendered insoluble in the soil, the more energetic will be its effect upon the turnip crop."

The above statements, made nearly 40 years ago, represent the views of one who was rightly regarded as an authority upon the properties and use of artificial manures, and it is interesting to note the extent to which these views have been realized in actual farm practice during succeeding years.

NEUTRAL PHOSPHATES.

In 1875, the Aberdeenshire experiments with finely-ground phosphates were instituted and conducted under the management of Prof. Jamieson for some years. The publication of the results excited much interest, for they demonstrated by actual field experiments that insoluble, or more properly termed undissolved phosphates, if applied in a finely-ground condition and in sufficient quantity, possessed very considerable fertilizing value, whereas, according to the previously held theory, such raw phosphates were supposed to possess no practical manurial value.

Further, these experiments proved that on certain soils, deficient in lime, ordinary soluble phosphate was not superior in its action as a manure to undissolved phosphates to anything like the extent that had hitherto been generally supposed.

Very naturally these novel results, being opposed to the theory hitherto held, excited a considerable amount of hostile criticism, which, however, time and more extended experience has proved to have been unreasonable and erroneous.

The experiments were carried out at five stations situated in different parts of the county of Aberdeen, and the soils are described in the official report as being "black mould resting upon a granite subsoil," and the analyses show that in every case they were specially deficient in lime. The figures for lime at these five stations were respectively 0.08, 0.17, 0.21, 0.33 and 0.38 per 100 parts of the dry soil.

These soils were in fact exactly those upon which soluble phosphate as supplied by superphosphate would not be likely to exert its full benefit, while the vegetable acids existing in the black mould would naturally dissolve the finely-ground mineral phosphate to a very considerable extent. In short, the conditions were most favorable to the action of undissolved phosphates, and most unfavorable to the action of dissolved or soluble phosphates.

The experiments in themselves, were, however, distinctly useful both scientifically and practically, and Prof. Jamieson will always be favorably associated with what must now be regarded as a step forward in the economical application of finely-ground neutral phosphates.

ALKALINE PHOSPHATE OR BASIC SLAG.

About the year 1883 the now well-known basic slag or Thomas phosphate powder was introduced to the agricultural world. It is the residual slag resulting from the treatment of iron ore by the Thomas-Gilchrist process of adding lime in order to remove the phosphoric acid and silica. Briefly it consists of basic phosphate of lime and basic silicate of lime, associated with some iron, manganese and magnesia compounds.

It has a distinctly alkaline character, but it is a mistake to suppose that this material contains any considerable quantity of free lime, because any such excess of lime would indicate a wasteful method of manufacture, lime being only added in sufficient quantity to remove the phosphorus and silica existing in the original iron ore.

Though but slightly soluble in ordinary water it dissolves to a certain extent in water impregnated with vegetable acids, and it is the neutralization of such acids which exist in sour grass that largely contributes to make its application so beneficial on certain kinds of soil.

No other manure has ever before occasioned so great a diversity of opinion as to its value as a fertilizer. When finely ground and applied to suitable land with sufficient water either in the soil or from rainfall, the results have been most satisfactory, both in the increased yield and in the improved quality of the grass and hay; but where the conditions are unfavorable and the land unsuitable, the results have been most disappointing. Indeed, when first introduced agricultural chemists of high repute were disinclined to place any fertilizing value on such a hard fused mass, however finely it might be ground, because it was so insoluble in ordinary water.

Little by little, however, farmers were induced to take small quantities for trial, chiefly on old and sour grass lands, and the practical results were so good on certain soils—rich in vegetable acids but poor in lime—that scientific authorities were soon compelled to recognize its value, and as the market price was low the material naturally became popular in certain localities.

In this country the importance of fine grinding has hitherto been recognized as the chief test of the probable manurial value, but in Germany, Prof. Paul Wagner, of the Agricultural Station of Darmstadt, has insisted upon the solubility in a 2 per cent solution of vegetable acid, such as citric acid, as a further and more definite test of probable manurial value.

Dr. Bernard Dyer, in his paper "On the Determination of Probably Available Mineral Plant Food in Soils" (Journal of the Chemical Society, 1894), has adopted a cold 1 per cent solution of citric acid for determining the portions of phosphoric acid and potash existing in a presumably available form in the soil.

The present writer, however, has selected as his standard solvent a 0.10 per cent cold solution, consisting of 1 part of citric acid to 1,000 parts of cold distilled water. Such a solution is twenty times weaker than that of Prof. Wagner, and ten times weaker than that of Dr. Dyer.

In fact, it represents an acidity absolutely below that of the sap of any of the 103 plants, examined by Dr. Dyer in the paper referred to, and it also more closely approximates to the natural acidity of ordinary soils than either of the standard solutions previously employed.

It is therefore contended that any phosphoric acid, lime or potash dissolved out by this standard solution, may be fairly regarded as existing in a form available as plant food, whether in a soil or in a manure.

In the following table the relative solubility in this standard solution of five different kinds of finely-ground raw phosphate, is compared with that of a good specimen of basic slag.

In each case, one gramme of the ground phosphate was exhausted with 1,000 grammes of cold distilled water, in which one gramme of crystallized citric acid had been dissolved.

After standing 24 hours with occasional stirring, the insoluble portion was filtered off, ignited and weighed, while the proportions of lime and phosphoric acid were determined in the clear solution.

MINERAL PHOSPHATES.

Solubility in cold weak solution of Citric Acid (1 in 1,000) after 24 hours.

	French.	Algerian.	Florida.	Tennessee.	Peace River.	Basic Slag.
Total phosphate of lime present...	50.86	55.99	78.26	79.57	61.23	38.97
Fine powder passed through 100 hole sieve.....	76.21	67.69	72.37	71.63	93.61	93.80
Portion soluble in citric acid solution.....	30.00	30.00	22.60	22.60	31.40	38.80
Containing—						
Soluble lime.....	15.34	13.66	11.87	11.64	15.23	22.17
Soluble phosphoric acid.....	2.85	6.35	8.25	8.40	9.90	8.70
Equal to phosphate of lime....	6.22	13.86	18.01	18.34	21.61	18.99

The above results show the percentage of phosphate of lime present in the respective samples, also the fineness of the grinding, the extent to which the respective specimens were dissolved by the cold, weak citric acid solution, and finally, the proportions of lime and phosphoric acid in its equivalent of phosphate of lime existing in the cold citric solution.

It will be seen that ground phosphates are only soluble, and therefore available as plant food to the extent of 22.60 to 31.40 per cent, and that the basic slag is only dissolved to the extent of 38.80 per cent, in fact only a little more than one-third of its weight, though it was of good quality, 38.97 phosphate of lime and 83.80 fineness.

As regards the actual amount of phosphate of lime dissolved out of the five specimens, the Peace River, with a fineness of 93.61, gave the highest figures for solubility, there being 21.61 phosphate of lime dissolved out of a total of 61.23.

In the case of basic slag, the figures, though relatively higher, are actually less, namely, 18.99 phosphate of lime dissolved out of a total of 38.97. These results explain why Prof. Jamieson, with the black vegetable mould to experiment upon, obtained an appreciable increase in the yield of turnips from the application of finely ground raw phosphates, though if we take the most favorable example, namely, Peace River, only about one-third of the total phosphates would have been utilized as available plant food and the remaining two-thirds was of no use to the crop.

The defect in the economical application of finely-ground phosphates is their insufficient solubility, and it is this want of solubility that is the defect also of basic slag when applied to many soils.

Before leaving these figures it is interesting to notice that it is only in the proportion of soluble lime that basic slag shows a superiority over that of Peace River phosphate, there being 22.17 per cent dissolved out as against 15.23.

Indeed, the fertilizing value of ordinary basic slag must be ascribed as very largely due to the ready supply of lime when the slag is brought in contact with sour soil, if accompanied by plenty of water either in the soil or from the rainfall.

It is well known that slag fails to produce any practical results on certain soils, and this failure is probably due partly to a deficient supply of water and partly to the absence of that excess of vegetable matter which is necessary to produce an acid solvent.

THE NEW MANURE BASIC SUPERPHOSPHATE.

It occurred, therefore, to the author, after careful consideration in the autumn of 1900, that a new and useful manure could be produced by the careful admixture of suitable proportions of ordinary acid superphosphate with finely ground or slaked lime.

After making numerous trial mixtures the most suitable proportions were decided upon, and a manure was produced which possessed a distinctly alkaline or

basic character, and at the same time supplied from 25 to 27 per cent of phosphate of lime in a form readily soluble in the standard solution (1 in 1,000) of citric acid.

The manure so produced was appropriately called basic superphosphate because it combined the alkaline nature of slag with the well-known solubility of superphosphate.

The mechanical condition is superior both to that of basic slag and superphosphate. Compared with the former it is much more bulky and lighter in weight, so that if equal weights be placed in two glass tubes about 1 foot long basic superphosphate will be found to occupy a space of 11 inches as compared with only 4½ inches occupied by basic slag, the relation in round numbers being as 100 to 40.

Compared with superphosphate the new material is very much drier, containing only 4 to 5 per cent of moisture instead of the 14 to 18 per cent usually found in commercial superphosphate.

Being in a finely ground dry powder of light weight and bulky nature, greater uniformity and more perfect distribution can be obtained than is possible with basic slag, which when sown by hand is apt to drop between the fingers before complete delivery can be effected.

Farmers will appreciate these advantages, and will be glad to be assured that there will be no danger of any clogging of the drill from damp condition, which in the case of badly made superphosphate is a very serious defect, and renders the uniform distribution of the manure quite impossible.

The general composition of basic superphosphate may be gathered from the following analysis:

COMPOSITION OF BASIC SUPERPHOSPHATE.

Moisture (lost at 212 deg. F.)	4.15
Combined water and loss on ignition	12.86
*Phosphoric acid (total)	13.60
Lime	35.15
Sulphuric acid	28.50
Oxides of iron, alumina, magnesia, etc.	2.34
Insoluble siliceous matters	3.40
	100.00
*Equal to phosphate of lime	29.68

The manure usually contains from 33 to 35 per cent of total lime, so that in this respect basic superphosphate supplies fully 10 per cent more lime than ordinary acid superphosphate.

The superior solubility in cold water of basic superphosphate compared with good basic slag, containing 38.97 phosphate of lime and 83.80 fineness, is shown in the following table:

Solubility in Cold Water after 48 Hours, 1 Part Manure to 1,000 Parts Cold Water.

	Basic Super.	Basic Slag.
*Portion soluble in cold water	66.80	6.60
Portion insoluble (after ignition)	33.20	93.40
	100.00	100.00

*Containing—

Soluble lime	22.28	4.70
Phosphate of lime	None	None

It will be seen that basic superphosphate is fully ten times more soluble in perfectly cold water than well ground basic slag, the figures being 66.80 against 6.60 per cent. Further, that there is 22.28 lime dissolved out in the former against only 4.80 in the latter.

These figures may, perhaps, explain why basic slag fails on certain soils, while it produces excellent results upon others. It is not ordinary water that is capable of decomposing a hard fused mass like slag, however finely it may be ground, but water impregnated with vegetable acids. In other words, it is only on sour acid soil that special benefit may be expected from the application of slag.

It will be noticed that no phosphate of lime was dissolved out by plain water from either manure, because on account of the presence of lime in excess, all the phosphate of lime was retained in a precipitated form in the basic super, and in a more insoluble form in the slag.

Solubility in (1 in 1,000) Citric Acid Solution (1 part Manure to 1,000 parts Solution) after 24 hours.

	Basic Super.	Basic Slag.
*Portion soluble in citric solution	94.20	38.80
Portion insoluble (after ignition)	5.80	51.20
	100.00	100.00

*Containing—

Soluble lime	34.73	22.17
Soluble phosphoric acid	12.45	8.70
Equal to phosphate of lime	27.18	18.99

The above figures show that when both manures were treated in exactly the same manner, in regard to the quantity and strength of citric acid solution, with the same time allowed in each case for exhaustion with the standard solvent, basic super was dissolved to the extent of 94.20 per cent, as against 38.80 per cent in the case of the basic slag. Further, 34.73 lime was dissolved in the former, against 22.17 in the latter. Lastly, 27.18 phosphate of lime was dissolved out of the basic super, against 18.99 out of the slag. The slag employed was the same as was used in all the previous experiments, and was of good quality and well ground. Though the slag contained 38.97 total phosphate of lime, only 18.99, or less than half, was dissolved by the standard solvent, and may therefore be considered to represent the proportion probably available as plant food.

It is very important to bear these figures in mind, and to remember that it is not the total amount of phosphate of lime present in slag that should be regarded as indicative of its manurial value, but the actual quantity that is likely to be available as plant food.

Hence, as a quick-acting manure, suitable for late

application in the spring, basic super must be regarded as far superior in fertilizing effect to ordinary slag, notwithstanding the high total contents of phosphate of lime contained by the latter.

THE UTILITY OF THE NEW MANURE.

Basic superphosphate can be applied, indeed has been applied in the season of 1901, with great advantage on soils deficient in lime, such as sand, gravel, granite, peat and clay.

Briefly, it may be stated that all soils containing less than 1 per cent of lime will be greatly benefited by the application of basic superphosphate instead of slag or ordinary superphosphate.

It is of practical importance to state that though originally invented to supplement the deficient solubility of slag, which is fully recognized by those interested in its sale (they therefore recommend its application during the winter months), it has been found by actual field results that the new manure is superior also to superphosphate on soils deficient in lime.

Mr. William E. Bear, of Magham Down, Hailsham, employing equal quantities of basic super and ordinary superphosphate, was able to obtain a growth of radishes, 66 per cent greater in weight by the use of the former manure, than he did by the latter.

In this case the soil contained, according to Dr. Bernard Dyer's analysis, only 0.68 of lime per cent in the dry state.

In another experiment on the farm of Mr. Ouston, near Grimsby, in Yorkshire, basic super used at the rate of 5 cwt. per acre, gave a specially good crop, and the soil on analysis was found to contain only 0.78 of lime per cent.

Mr. Edward Packard, at Saxmundham, obtained by the application of 5 cwt. of basic super per acre, 18¼ tons of swedes, against 15 tons produced by 5 cwt. of slag, and 14¼ tons from the no manure plot, the soil in this case containing 1.75 lime per cent.

It is well known that soils subject to the disease known as finger and toe in turnips, are naturally deficient in lime, containing in fact considerably less than 1 per cent, and on such soils it is reasonable to suppose that an alkaline phosphate manure would naturally be a more suitable dressing than an acid phosphate manure such as superphosphate.

During the season of 1901 numerous instances were recorded in which basic super has been used on such soils with very marked advantage, the virulence of the disease being materially reduced, and in some remarkable cases in Scotland, its application has completely prevented any attack, while other parts of the field manured with ordinary superphosphate had suffered very much from the disease.

In connection with this subject, it may be convenient to point out by means of the following tabulated figures, the relation in which lime and phosphoric acid are respectively removed from the soil by ordinary farm crops.

LIME AND PHOSPHORIC ACID REMOVED PER ACRE BY FARM CROPS.

	Lime, Pounds.	Phosphoric acid, Pounds.
Clover hay, 2 tons	85	25
Turnips, root, 17 tons	25.5	22.5
leaf	48.5	10.5
Mangels, root, 22 tons	24.0	34.0
leaf	29.0	15.0
Swedes, root, 14 tons	19.5	17.0
leaf	22.5	5.0
Beans, grain, 30 bushels	3.0	22.5
straw	30.0	9.5
Meadow hay, 1½ tons	28	13
Potatoes, tuber, 6 tons	3.0	24.0
haulm	23.0	3.0
Oats, grain, 45 bushels	2.0	12.0
straw	10.0	7.0
Wheat, grain, 30 bushels	1.0	14.5
straw	10.0	8.5
Barley, grain, 40 bushels	1.5	15.0
straw	8.5	5.0

It will be seen that in respect of an average crop of clover, hay, turnips, mangels, and swedes, lime is relatively required in greater proportion than phosphoric acid. It is useless, therefore, to expect to grow good crops, or crops free from certain diseases, if there is a deficiency of lime.

On the other hand, it would appear that wheat, barley and oats require phosphoric acid in greater proportion than lime, though the actual quantities are much less than in the case of root crops or clover hay.

This table of figures is also useful in illustrating the great waste of applying lime in large quantities, such as 3 or 4 tons per acre, for the actual crop requirements would appear to be less than 100 pounds per acre.

If 2 or 3 hundredweight of superphosphate are considered sufficient to supply the requisite quantity of phosphoric acid, surely 3 or 4 hundredweight of lime should be sufficient to supply the requisite quantity of lime.

Of course this remark only applies to the application of lime to ordinary well-drained soil, and not to damp sour grass land where the natural acidity of the soil would require larger dressings of lime.

But under ordinary conditions large dressings of lime are practically wasted because the slaked lime, which is not absorbed by the soil or the plant, rapidly becomes converted into carbonate of lime, in which form it is but little soluble in ordinary water.

Usually where the soil is deficient in lime, the cost of its application is very great by reason of carriage from a distance, and in all such cases basic superphosphate will be found particularly useful and decidedly economical, because in addition to supplying from 25 to 27 per cent of phosphate of lime in a form sufficiently soluble to afford available plant food, it also supplies an appreciable dressing of caustic lime.

How beneficial small dressings of alkaline ashes are may be inferred from the practice in India of burning the stubbles after the removal of the corn and previous to the usual rainfall.

In this country the custom of collecting and burning the common couch grass (*Triticum Repens*) is to be highly commended as being not only the most effectual way of eradicating this troublesome weed, but as being a cheap means of supplying valuable alkaline ashes to

the soil; for these ashes materially assist that important bacterial action whereby the inert vegetable matter of the soil is converted into valuable fertilizing compounds such as nitrates.

A strong argument in favor of the utility of alkaline phosphatic manures is afforded by the fact that all the natural manures hitherto used in agriculture are distinctly alkaline. Thus, farmyard manure, in the efficacy of which farmers thoroughly believe, is alkaline, and its agricultural value depends upon the extent to which the nitrogen compounds are converted by proper fermentation into ammonia salts. Guano, especially the good old Chinch Peruvian quality, is thoroughly ammoniacal.

Bone dust, dried blood, woolen waste and shoddy, also soot, and lastly lime, are all more or less alkaline in their nature, and certainly not acid.

Moreover, it is hardly necessary to repeat that basic slag is itself a striking instance of the utility of alkaline phosphate of lime as a manure for certain soils.

Indeed it is not natural that manures should be acid, and the reason why ordinary acid superphosphate has been beneficial to crops grown on good arable land, is that the acidity of the manure has been absorbed or neutralized by the abundance of lime usually present in such soils.

Obviously, where the soil is deficient in lime the acidity of superphosphate cannot be immediately absorbed, and harm may be done to the young rootlets of the plant.

It would require a very heavy dressing of lime to saturate the soil so completely that every square inch of surface should always contain the necessary quantity of lime requisite to absorb the acid from every particle of manure that may be brought in contact with it. In other words, it is much more economical to add lime in small quantity to the manure for the purpose of immediate and complete neutralization, than to add lime in large quantities and at long intervals to the soil in order to provide a wasteful excess of alkali for the absorption of a minute quantity of acid.

The necessity of relying upon a sufficiency of lime in the soil is entirely removed when using basic superphosphate, as by the careful admixture of an excess of lime in its manufacture all acidity is removed and the manure may be applied, mixed directly with the seed without danger of destroying the vitality of the same.

As a practical demonstration of the injurious effects produced by the continued annual application of acid salts, it is only necessary to refer to the report on the Woburn experiments by Dr. Voelcker in the last number of the Journal of the Royal Agricultural Society, in which a photograph is given of absolutely barren spots where the barley crop had entirely failed in consequence of the annual application of sulphate of ammonia to a ferruginous sandy soil. These barren spots were evidently due to the local accumulation of acid compounds and the absence of sufficient lime, for on the adjoining plot, which had received the same quantity of ammonia salts annually, but had in addition received a dressing of lime, the barley was looking thoroughly healthy.

On such soils as that at Woburn, basic super, which, in addition to phosphates, supplies some caustic lime, will naturally be more suitable than ordinary super, and when it is remembered that four-fifths of the former consists of ordinary superphosphate, the manufacturer will find it to his interest to supply the new manure. Indeed, on all light sandy ferruginous soils manufacturers are at present in an awkward position, because acid manures being unsuitable it follows that an alkaline manure, superior in its fertilizing properties to basic slag, should be supplied, as otherwise no practical opposition to the use of slag is available.

Basic superphosphate has the advantage that it can be mixed with nitrate of soda without any fear that the valuable nitric acid will be decomposed or driven off by an excess of acid, and the resulting compound is in an excellent dry powdery condition, admirably adapted to secure uniform distribution as a top dressing.

During the season 1901, the manure has been sold in 187 places in England, 72 in Scotland, and 13 in Ireland. Many of the deliveries so included were in quantities of 10 to 20 tons, consigned to agents, so that the actual local trials have been still more numerous.

The practical results obtained in the field have, notwithstanding the dry season, been most encouraging, and have fully realized the favorable opinion originally formed from the analytical results.

CONCLUSION.

In conclusion, it should be mentioned that basic superphosphate is not intended to supersede ordinary acid superphosphate upon soils containing plenty of lime, nor is it intended to take the place of well ground slag for application to damp sour land; but it is rather intended to take an intermediate position between these two well-known and most useful manures, and to be employed as a quick acting alkaline phosphate manure, specially useful as a spring dressing for crops grown upon soils that contain less than 1 per cent of lime, the united acreage of which represents such a large area of the cultivated land in the United Kingdom.

The utility of alkaline phosphate manures when applied to certain soils has already been practically demonstrated by the great success that has attended the use of basic slag, notwithstanding its slow solubility, its frequently defective grinding, and recently, its reduced percentage of phosphate.

If therefore a material of similar alkalinity, but of greatly superior solubility, can be obtained in an unlimited quantity, and of uniform quality, it is reasonable to anticipate that basic superphosphate will prove to be a really useful and most valuable additional fertilizer.

The time has come when manures should be adapted to the soil, rather than that the soil should adapt itself to the manure.

Obviously, soils differing so much in their chemical composition and physical character, as chalk and clay, peat and sand, granite and gravel, require different

manures, in the same way as they require different cultivation and different kinds of crops.

It is not scientific, it is not economical, and it cannot be to the advantage of the farmer, that one kind of manure should be sold for application to all kinds of soils.

Acid manures may with advantage be applied where there is plenty of lime, and alkaline manures may be more profitably applied where lime is deficient.

SOME LOCOMOTIVE SHOP TOOLS.

THE engraving shows a spring testing machine, made by Joshua Buckton & Co., of Leeds, which will not only weigh and measure the deflection of the spring, but will give it a rapid action such as it would encounter in running on a permanent way, and will then exactly weigh and measure the falling off in the spring if there should be any. It is designed to test laminated springs, helical springs, and volute springs up to 12 tons pressure, up to 7 feet 6 inches long and 1 foot 4 inches high. The maximum stroke is 15 inches, variable down to 3 inches, and the ram can be driven either at ten strokes a minute for accurately calibrating the resilience of the springs, or at 150 strokes per minute for testing the power of the springs to withstand rapid vibrations. The end

locomotive fireboxes a special swiveling table is used in conjunction with this machine. There is a pit at the back of the main table, which can be swiveled until it is in a vertical plane like the face plate of a lathe, or in a horizontal plane. The table itself has a circular motion, controlled by a worm and worm wheel, so that all four sides of a locomotive fire-box can be drilled at one setting of the table. Holes, in fact, at any angle whatever can be drilled in the work while the spindles of the machine remain vertical.—The Engineer.

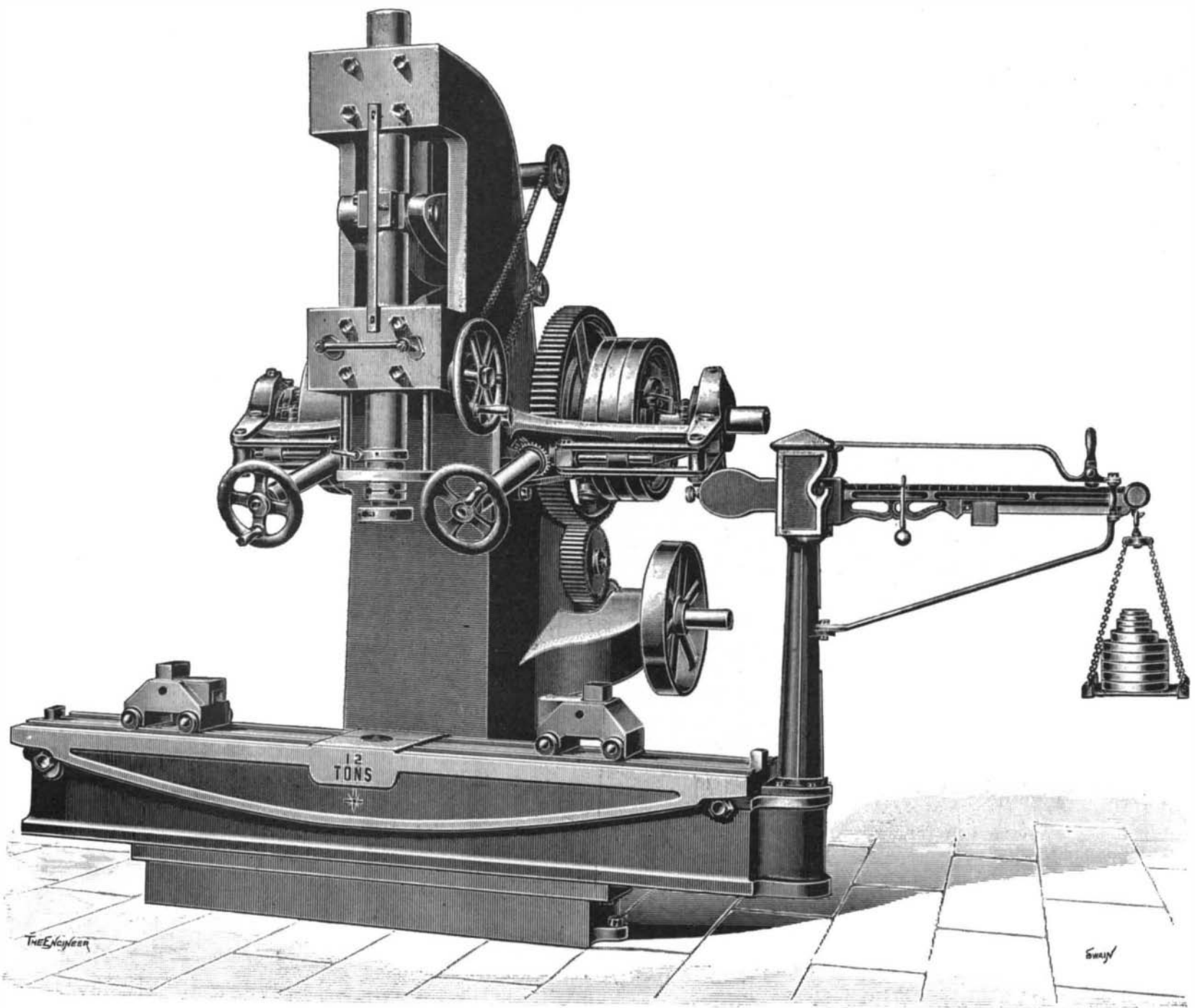
REPORT ON THE METRIC SYSTEM.

THE report of the committee on the bill providing for the adoption of the metric system by the government of the United States has been completed. The report advocates the reforming of our systems of measurements.

A complete statement of the weights and measures in common use would not only be difficult to make, but would involve more space than is available in a brief report. It is sufficient to state, however, that the various units have been inherited from a time when exact measurements were unheard of, computations were seldom made, and when each locality and different interest had its own system of measures. Modifications and adjustments have been made from time to time; never-

tems of weight, the apothecary, the troy and the avoirdupois, to illustrate this fact. And while the yard may be stated as our standard of length, we find in practice various arbitrary multiples of the yard and foot; for example, the fathom, the surveyors' and engineers' chains, the nautical and statute miles, hands, poles, perches and various others. In addition to the ordinary cubic measure we find three systems of measuring capacity: dry measure, liquid measure and apothecary's fluid measure. To these might be added a large number of technical standards in use in the various trades and industries, which would be greatly simplified and unified upon the adoption of the international system of weights and measures. An examination of the common tables of weights and measures discloses the fact that there are 64 different ratios used, of which 19 are not divisible by two, and that there are 18 terms used which have two or more meanings. Certainly any effort on the part of Congress to replace this conglomerate system with a simple, logical one similar to our monetary system is worthy of the consideration of Congress.

The metric system of weights and measures was devised as an international system. The fact that it was first adopted by France has given rise to the custom of referring to it as the French system. It is interesting to note, however, that one of the first to propose a decimal system of weights and measures was James



TAFF VALE RAILWAY--SPRING TESTING MACHINE.

of the ram is fitted with a screw adjustment to suit varying heights of springs. The pressure from the ram is arranged to act upon the springs through the same pin holes, which the weight of the rolling stock bears upon in actual running, so that buckles, eye-lets, and other attachments are tested at the same time as the spring itself. When the machine is testing the springs with its rapid action the springs are made to vibrate through a range of 3 inches or 4 inches without the removal of the load, so that the spring and all its attachments are acted upon with the same violence as they would encounter if running at sixty miles an hour over 30-foot rails with imperfect joints. This machine is in use at the works of the Taff Vale Railway, Cardiff.

A radial drilling machine for boiler work is shown in another engraving. The special advantage of this machine is that it will drill two holes at a time at any distance from each other between 7 inches and 5 feet. The headstocks carrying the drill spindles have a motion of 14 inches at right angles to the main jib of the machine—an exceptional arrangement which may be readily overlooked in the engraving. This enables lines of parallel holes to be drilled without swinging the main jib. The spindles are reversible for tapping, and all the handles controlling the machine are near the end of the jib. For drilling

theless, the system is full of inconsistent ratios, the units are not related to each other, many units of the same name have different values, it is unsuitable for computation and is not decimal in character. This last defect has sometimes been urged in its favor, but it is difficult to comprehend how anyone familiar with the subject should advocate any other than a decimal system of weights and measures in connection with a decimal system of numbers. It may be true that a system of weights and measures in which a binary subdivision is followed might be better in a few instances, but, on the whole, experience has shown that the advantages to be gained by a decimal system far outweigh those of any other. However, it should be noted that a binary system of subdivision is but seldom followed in our common system of weights and measures, and further that a decimal system is capable of this method of subdivision, as illustrated by the use of halves and quarters in the metric system of measures and in all decimal systems of money.

It is a popular fallacy that our weights and measures are in accord with those of Great Britain, but this is not true, as neither our pound, the yard, the gallon nor bushel are identical.

Very few people are familiar with the weights and measures in common use in the United States. One has but to recall the tables of our three different sys-

Watt, the inventor of the steam engine, and the adoption of a decimal system of coinage by the United States was one of the strongest influences leading to its adoption. As originally proposed the unit of length in the metric system was called the meter and defined as the one ten-millionth part of the distance from the equator to the pole of the earth measured on a meridian. The first of these units to be constructed was by the French government and was based upon the best known measurements of the earth's surface at that time. Subsequently more accurate measurements of the earth's surface showed that the meter as first constructed was not of the length intended nor was its material or form such as required by modern refined measurements.

To remedy this defect an international congress was held in Paris, 1875, 17 different nations participating. It was thought best to retain the length of the old meter. Accordingly a number of copies were constructed of the best material and method of construction known to science. One of these was selected as the international meter and is very carefully preserved at the International Bureau of Weights and Measures, established and maintained by the countries participating in the congress and those which joined the convention later. These meters were very carefully compared with the one selected as the inter-