CHEMISTRY

Food for the Land

TVA Turns an Ammunition Plant to the Task of Making Restorative Phosphates for the Farmer's Depleted Soil

By DR. FRANK THONE

TVA, in the minds of most people, symbolizes just two things: electric power, and a stand-up, knock-down, drag-out politico-legal fight about that power.

This is not at all an accurate picture, but it is the most widely-apprehended one. Yet the spectacular struggle-aspect of the TVA could be subtracted from the situation, and still leave TVA as one of the most significant movements that has ever entered the pageant of American history. Power is not needed, to make the work of the Tennessee Valley Authority a very powerful thing, both in its effects on the lives of the people in the Valley and in its ultimate potencies for the lives of all the rest of us.

Take away the "P" for Power, in the TVA set-up, and you will still find the same mump-faced capital letter, this time in the chemist's symbolism: P for Phosphorus. Phosphorus is a chemical element little familiar to most of us, yet one without which none of us could live.

Phosphorus is flesh of our flesh, and even more emphatically bone of our bone: our skeletons are composed largely of calcium phosphate. To obtain this all-necessary life-element we have to depend on plants, and the plants in turn have to depend on the phosphates their roots search out in the soil.

In Verse

Hence the very great importance of phosphorus in any scheme of soil fertilization. When the late Rudyard Kipling many years ago wrote a bit of macabre verse about

"And he who wrote on phosphates for
the crops
Is subject-matter of his own report,"

he showed a knowledge of agricultural chemistry as well as of poetry. In the normal economy of nature, the skeletons of animals, small and great, return to the earth from whence they came, and the cycle of phosphorus thus remains unbroken.

But civilization breaks the cycle in several spots: wheat and cotton are shipped abroad, the animals go to the slaughter-house and their skeletons do not come back, we ourselves are buried in cemeteries—and too deep for the roots to find us, at that. So the phosphorus content of the soil goes down and down, and the crops become starved and more starved.

Not that phosphorus is the only element of which the soil is robbed by "money-crop" cultivation. Plants need, in addition, nitrogen, calcium, magnesium, potassium, sulphur, and a little bit of iron. All soils need to have their nitrogen content renewed, but fortunately that can be done by the nitrogen-catching bacteria that live on the roots of clover, beans and other legume crops.

Most soils have sufficient reserves of magnesium and sulphur, apparently, for a long time to come. But most of the Tennessee Valley soils and many soils in other parts of the United States are desperately poor in phosphorus. Calcium, or lime, is also needed to "sweeten" these soils and make the other food elements more available to plants.

That is why the agricultural division of TVA, after a critical study of all factors involved with the cooperation of the U. S. Department of Agriculture and state agricultural authorities, picked upon phosphorus as the key to unlock the shackles of poverty that drag upon the limbs of farming in the Valley. What phosphorus can do in the Valley, it should also be able to do in many other areas.

This is not the only factor in a bad situation. The Tennessee Valley is a pretty fair cross-section of much of the nation. Soil poverty, soil erosion, stranded mountain populations and degrading cotton tenancy are representative problems of the Valley.

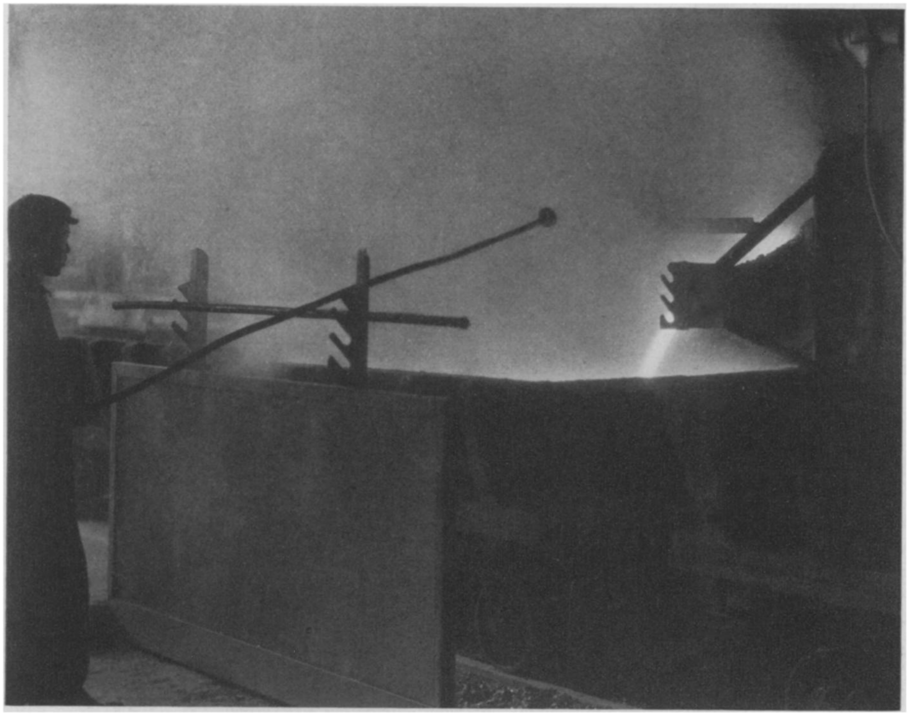
Rich Soil

On the other hand, the Tennessee watershed contains abundant water-power resources, some of the country's richest soil and a few examples of good agriculture prosperously coordinated with industry.

TVA is helping the Valley people make counter attacks against all these ills, but soil poverty was selected as the crucial link in the chain, and phosphorus was to be forged into the hammer that could break it.

HAND POWER

Digging phosphate rock from Tennessee deposits. Much of the work is done by hand though power shovels are employed to some extent. An over-burden of soil has to be stripped away. Dump cars on narrow-gauge track carry the rock to standard open freight cars.



ANOTHER STEP

Tapping slag from one of the 6,000 kilowatt electric furnaces in Muscle Shoals Plant No. 2 in which phosphate rock, coke and silica are fused as the first step in a process that yields high strength phosphoric acid. After cooling, the slag is crushed for use in road building or as a concrete aggregate.

This was determined partly by the nature of the terrain, and partly by the forces available—as any well-planned battle is determined. TVA had inherited two war-time plants at Muscle Shoals, neither of which had ever manufactured a ton of the nitrates for which they were first designed. No. 1 Plant had become obsolete, but No. 2 Plant still stood in good running order, with twelve great electric furnaces, that could be the heavy artillery of the fight.

Ammunition was not lacking. While newer processes made the original plan to turn out nitrates rather impracticable, the furnaces could be adapted for the production of phosphate fertilizers, and there was plenty of phosphate rock in the Valley's hillsides not very far from Muscle Shoals.

Rich Rock

The phosphate rock is in the Great Basin section of Tennessee where the soils, like those of Kentucky's blue grass lands, are among the richest in the nation because they were formed from underlying phosphate rock. TVA wants to show that rich-land prosperity can be established on lands that are now poor by artificial application of phosphate.

The phosphate rock deposits in Tennessee are not the largest in the country. Florida has larger beds, and the Far West, particularly Utah, immensely larger ones. In fact, about 95 per cent of all known phosphate beds in the country are in the West—they constitute nearly two-thirds of all the known deposits of really high-grade phosphate rock in the world.

The Process

But the Valley still afforded plenty of phosphate rock to feed the furnaces. TVA contracted with farmers who owned deposits to mine them when they could not work in their fields, and stored the broken rock in great piles near No. 2 Plant. Fed with phosphate rock, coke, and silica, the furnaces yield, by present methods of operation, phosphoric acid. This is mixed with finely ground phosphate rock, and the product is one form of "triple superphosphate."

The story of phosphate fertilizers is worth telling, step by step.

The raw phosphate rock, as dug in the Tennessee Valley and elsewhere, contains a fair amount of phosphorus. Powdered and put on the land "as is," its plant food would become available so slowly that its use would scarcely be practicable. It is also entirely too bulky in relation to the amount of available plant food it contains to pay for long transportation.

The powdered rock is commonly converted into superphosphate by adding sulphuric acid. This common superphosphate averages from 7 to 8.7 per cent of actual phosphorus content.

"Triple-Superphosphate"

There has also been on the market a "triple-superphosphate" fertilizer of up to 18 or 20 per cent actual phosphorus concentration which is made by adding phosphoric acid of 45 to 55 per cent strength to the powdered raw material. The product is moist and gummy and has to be aged and dried before it can be handled. It has never been particularly popular with farmers. They do not realize that, although this material is higher in price per ton than regular superphosphate, it is cheaper per unit of plant food and therefore more economical.

The TVA phosphate plant has been experimenting with a triple-superphosphate made by an improved method. This has proved successful in limited tests and now is being tried out under actual farm conditions. A new phosphatic compound stepping up the content of elemental phosphorus to about 28 per cent is now being tested as a fertilizer at experiment stations. TVA's triple-superphosphate has been made possible by development of a method of mixing high strength phosphoric acid with ground phosphate rock to yield a dry, easily handled product.

What comes out of the rock in the electric furnace is the elemental phosphorus itself in gaseous form at high temperature. At ordinary temperatures phosphorus is a waxy, stiff stuff that burns spontaneously if left exposed to air. At present it is permitted to burn and form the chemical compound phosphorus pentoxide, which is converted into concentrated phosphoric acid for mixing with ground phosphate rock.

Other Uses

But there is no good reason why this valuable, 100 per cent pure elemental phosphorus should not be turned to other purposes. For one thing, it realizes in a new way the purpose for which the plant where it is made was constructed during the World War—a support for the national defense. Phosphorus has several uses in chemical warfare, particularly in the formation of smoke-screens.

It also has many industrial uses, and since it is so concentrated it may be shipped to distant points to be converted into fertilizer, where the freight charges would be too heavy even on

APPLICATION

Ready to doctor sick land with essential plant foods and in so doing test the value of TVA's new phosphate in practical farm use. State College supervision requires that the phosphate be used with supplementary materials that increase its value, such as lime, and provision is made for comparison with untreated plots and with plots treated with other phosphate materials.

superphosphates of the best present grades.

The two electric furnaces now in use at Nitrate Plant No. 2 can produce 20 tons of pure phosphorus a day, or about 6,000 tons a year. Any or all of the ten other furnaces in this plant could at need be put to the same purpose, or could manufacture calcium carbide, high-grade steels, and abrasives and refractories.

Thus, TVA's field of activity is to improve the methods of making fertilizer and to encourage farmers to use phosphates, plus lime from the limestone ledges that abound everywhere, as a means for building up their depleted land.

Since "seeing is believing" with farmers as with the rest of us, the demonstration method is used. State college farm agents, who have gained the confidence of farmers through years of work with them, supervise the demonstrations. In fact, these TVA-encouraged activities are but reinforcements for the drive toward good farming that the county agents have been carrying on for years.

Local Demonstrators

There is a farmer demonstrating soil-building in practically every community of the Tennessee Valley. They were chosen by neighbors organized into county soil conservation associations. Other farmers, seeing this phosphate-lime program work for the demonstrators, are beginning to apply it to their own farms.

Even within this restricted agricultural activity, TVA further restricts itself. Its phosphates are not for use on "row-crop" fields—corn, cotton, tobacco, or any of the so-called soil-depleting crops. These to be sure do need fertilizer, but for them the demonstration farmer as well as all others must obtain phosphates from private sources.

In fact, the demonstration program is increasing rather than decreasing the use of commercial fertilizers, including phosphates.

But for the plantings that build the land instead of exposing it to water erosion and sucking the mineral "juice" out of it at the same time—for pasture grass, for clover, lespedeza, cowpeas, soybeans and other legumes, the demonstration farmer gets TVA phosphates free.

That "free" has a string or two tied to it, for TVA isn't in the Santa Claus business. The phosphates are free—at the hopper-mouth in the No. 2 Plant warehouse. The farmer, who has been chosen by his neighbors, must provide handling, and pay freight by truck or railway. He must furnish ground limestone to put on the field with the phosphate, and purchase seed for the land-building crops. He must also keep books on his farm operations—all these things under the supervision of his state college agricultural authorities and the soil conservation association through which he was appointed.

This cooperative program has succeeded so well thus far, that farm communities outside the Valley have begun asking for the privilege of sharing in it.

The cover photograph is of a phosphoric acid plant, showing storage bin and the tall stack from which waste gases are released.

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ZOOLOGY

Hardship in Youth Prolongs Life of Lowly Animals

HARDSHIP in youth is a good thing—for some of the lower animals at least. Half-fed through their infancy, cladocera or water-fleas live longer and more vigorously after they have passed middle life, experiments by Dr. Lester Ingle and Prof. A. M. Banta of Brown University have shown.

Cladocera are not fleas, though they do live in the water. They are really crustacea—minute relatives of lobsters, crabs, and crayfishes. They are particularly well adapted to biological experimentation, because they are perfectly content to live in bottles on laboratory shelves. Requiring very little room per individual, they can be studied in statistically significant numbers.

"The essence of Dr. Ingle's results is that limitation in quantity of food keeps the cladocera in a youthful condition," Prof. Banta said, "so that when they are well fed in later life, beginning at a time when most of the animals have 'lived rapidly' on abundance of food and have already died, these previously semi-fed animals assume rapid rates of growth and reproduction. In a way, their active life is just beginning. They are still young animals.

"As judged by the effects upon longevity, the most favorable period for the 'abundant life' is not during the earlier part of life, but at a later period