America's Gibraltar

Muscle Shoals

In War—
Preparedness *for the* Nation

GOVERNMENT ENGINEERS DRILLING AT SITE OF DAM NUMBER TWO

America's Gibraltar
Muscle Shoals

—A Brief—
For the establishment of our
National Nitrate Plant at
Muscle Shoals on the
Tennessee River

Prepared by
Nashville Section
Engineering Association *of the* South
Published by
Muscle Shoals Association
Nashville, Tenn.
1916

The Law

SIXTY-FOURTH CONGRESS FIRST SESSION

Senate Document No. 442

Being an Extract from Section One Hundred Twenty-four of the Measure entitled "A Bill to Increase the Efficiency of the Military Establishment of the United States." (H. R. 12766.)

* * * *

NITRATE SUPPLY. The President of the United States is hereby authorized and empowered to make, or cause to be made, such investigation as in his judgment is necessary to determine the best, cheapest, and most available means for the production of nitrates and other products for munitions of war and useful in the manufacture of fertilizers and other useful products by water power or any other power as in his judgment is the best and cheapest to use; and is also hereby authorized and empowered to designate for the exclusive use of the United States, if in his judgment such means is best and cheapest, such site or sites, upon any navigable or non-navigable river or rivers or upon the public lands, as in his opinion will be necessary for carrying out the purposes of this Act; and is further authorized to construct, maintain, and operate, at or on any site or sites so designated, dams, locks, improvements to navigation, power houses, and other plants and equipment or other means than water power as in his judgment is the best and cheapest, necessary or convenient for the generation of electrical or other power and for the production of nitrates or other products needed for munitions of war and useful in the manufacture of fertilizers and other useful products.

The President is authorized to lease, purchase, or acquire, by condemnation, gift, grant, or devise, such lands and rights of way as may be necessary for the construction and operation of such plants, and to take from any lands of the United States, or to purchase or acquire by condemnation, materials, minerals, and processes, patented or otherwise, necessary for the construction and operation of such plants and for the manufacture of such products.

The products of such plants shall be used by the President for military and naval purposes to the extent that he may deem necessary, and any surplus which he shall determine is not required shall be sold and disposed of by him under such regulations as he may prescribe.

The President is hereby authorized and empowered to employ such officers, agents, or agencies as may in his discretion be necessary to enable him to carry out the purposes herein specified, and to authorize and require such officers, agents, or agencies to perform any and all of the duties imposed upon him by the provisions hereof.

The sum of $20,000,000 is hereby appropriated, out of any moneys in the Treasury not otherwise appropriated, available until expended, to enable the President of the United States to carry out the purposes herein provided for.

The plant or plants provided for under this Act shall be constructed and operated solely by the Government and not in conjunction with any other industry or enterprise carried on by private capital.

* * * *

MUSCLE SHOALS ASSOCIATION

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Foreword

THE AMENDMENT providing for an adequate means for the manufacture of nitric acid, which was incorporated in the National Defense Bill recently passed by Congress, is a feature of vital importance. It makes possible an abundant supply of nitric acid for our country's defense, and as nitric acid is an indispensable ingredient in all explosives, the provision is essential to any scheme for effective military preparedness.

Highly significant, however, is the fact that this amendment was provided, not by the Committee on Military Affairs, but by the Committee on Agriculture, for thus was emphasized a great need of our country - a need both military and economic in its nature, for this preparedness for the possible emergency of war is at the same time, a fundamental provision for the common welfare in time of peace.

OUR NATIONAL REQUIREMENT

Whether, then, we consider our requirement in peace or in war our country's nation-wide deficiency can be expressed in a single word *nitrogen*.

Public attention was officially drawn to this subject by Hon. Lindsley M. Garrison, Secretary of War, when in his annual report for 1915 he referred to the use of hydro-electric energy in the process of obtaining nitrogen from the air as a matter of "prime importance" in considering the means "to meet our necessities in widely differing fields—our agricultural and general industrial development, and our national defense." Continuing, he said:

> "Such a use requires large quantities of cheap power, which can be found only in the use of water power * * * Military effectiveness requires ample quantities of the element (nitrogen), and the proper appreciation of national security behooves us to make provision for an adequate supply in time of war. Our only present source of supply is in the natural nitrate beds of Chile, which in time of war might be shut off from us. Obviously in the matter of munitions, especially where the source is so limited and localized, we should neglect no provision so easily available as this to make the country self-sustaining. Plants producing nitrogen for industrial purposes in time of peace would be a great national asset in view of their availability to supply us with the necessary nitrogen in time of war."

THE PLAN ADOPTED BY CONGRESS

Realizing the need for taking immediate steps to overcome so serious a national deficiency, Congress amended the military preparedness bill so as to include an appropriation of $20,000,000 for the establishment of a nitrate plant, the two-fold purpose being to insure to the government a safe and sufficient supply of nitrogen in the form of nitric acid for the manufacture of explosives, and to provide an abundance of cheap fertilizer, of which nitrogen is the necessary base, in order to increase and cheapen the food production of the country. This plan of Congress is no experiment. It has been tried by other nations with wonderful results. It is no secret that the amazing effectiveness of Germany in military and economic preparedness is largely due to their utilization of atmospheric nitrogen.

The plan has met with opposition, but it will be shown that this opposition is limited, self-interested and ill-founded. The public welfare is paramount, and cannot be disregarded at the behest of any private interest.

THE LOCATION OF THE PLANT

The Government having declared its purpose, the very important question to be decided by the President and his counsellors, is the location of the nitrate plant.

We are confident that we can demonstrate that the South offers an exceptionally suitable site on the Tennessee River for the proposed plant; a site that will afford ample water power, with all the necessary associated and contributing natural resources and industrial advantages to make it preëminently fitted for the purposes contemplated by Congress.

In addition, the establishment of the nitrate plant at Muscle Shoals will remove the last obstacle to the unimpeded navigation of the Tennessee River and will provide water transportation for a great section of country, thus completing a necessary, but long delayed, waterway improvement.

THE PURPOSE OF THE ASSOCIATION

And so, to point out the far-reaching significance of one small item in a voluminous measure on Military Preparedness: To awaken our farmers and their many friends to the pressing need of leaving nothing undone that will rightly aid in establishing this great nitrate plant where it will have its maximum economic usefulness: To draw from reliable sources* the information that unfolds our subject in its many phases, and points unerringly, we believe, to one great power site as the place for the working out of this vast undertaking: To lay these facts clearly before our President and his chosen advisors, and to distribute them for general information: This is the purpose to which we dedicate these pages.

THE COMMITTEE.

*References to authorities take the form (A B) where A is a number indicating a publication listed on pp. 61-62 and B is the page in that publication on which the supporting data are to be found. In certain instances (e. g. magazine articles) the page number has been omitted.

Scientific and Commercial Endorsement

THE FOLLOWING ORGANIZATIONS OFFICIALLY ENDORSE MUSCLE SHOALS AS THE LOGICAL SITE FOR THE GOVERNMENT NITRATE PLANT

GENERAL

Southern Commercial Congress, Norfolk, Va.; Leland Hume, Chairman, Committee on Resolutions.

Southern Newspaper Publishers' Assn., Asheville, N.C.; W. T. Anderson, President.

Farmers' Educational and Cooperative Union of America, Palatka, Fla.; C. S. Barrett, President.

ALABAMA

Alabama, State of—John Purifoy, Secretary of State.

Albany—City Council; Henry Hartung, City Clerk.

Aliceville—Commercial Club; A. S. Murphy, President.

Athens—City Council; Ernest Hine, Mayor.

Attalla—Chamber of Commerce; John P. Stewart, Chairman of Committee.

Bigbton—City of Bbcton; J. A. Wood, Mayor.

Brewton—City Council; D. B. Hayes, City Clerk.

Dothan—Rotary Club; R. W. Lindsey, Secretary.

Ensley—Ensley Club; J. J. Chisholm, George Miller and D. C. Averyt, Committee.

Fort Payne—Chamber of Commerce; C. A. Wolfe, Secretary.

Jasper—Chamber of Commerce; Chas. R. Wiggins, Secretary.

Mobile—Chamber of Commerce; W. M. Clemens, Secretary.

Montgomery—Chamber of Commerce; Bruce Kennedy, General Secretary.

Selma—City Council; Louis Benish, Mayor.

Sylacauga—City Council; T. P. Johnson, Mayor.

CALIFORNIA

Long Beach—Merchants' and Manufacturers' Assn.; L. P. Steepleton, Secretary.

Los Gatos—Merchants' Association; E. E. Place, President.

COLORADO

Lamar—Young Men's Business Association; G. L. Carrico, Secretary.

Lamar—Arkansas Valley Credit Association; G. L. Carrico, Manager.

CONNECTICUT

Danielson—Business Men's Association; C. H. Starkweather, Secretary.

FLORIDA

Tampa—Board of Trade; L. P. Dickie, Secretary.

GEORGIA

Georgia, State of—Phillip Cook, Secretary of State.

Americus—Americus and Sumter County Chamber of Commerce; Carr S Glover, President.

Griffin—Retail Merchants' and Business Men's Association; George A. Nyles, President.

INDIANA

Greensburg—Business Men's Association; Harry Lathrop, Secretary.

Indianapolis—Indiana Engineering Society; L. M. Wallace, President.

Rushville—Rush County Chamber of Commerce; Horatio S. Haven, President.

KENTUCKY

Bardstown—Nelson County Business Men's Association; Jacob S. Heyman, President.

Cadiz—Trigg County Development Association; A. G. Bennet, Secretary.

Fulton—Commercial Club; J. D. Davis, Secretary.

Jackson—Business Men's Club; Wm. W. Perryhouse, Secretary.

Lagrange—Business Men's Club; Ben J. Morris, Secretary.

Lexington—Board of Commerce; H. L. Burch, Secretary-Manager

Mayfield—Mayfield and Graves County Commercial Club; J. W. Kevil, President.

Owensboro—Owensboro-Daviess County Industrial Club; C. J. Kellem, Secretary.

Paducah—Board of Trade and Retail Merchants' Association; C. W. Craig, Secretary.

Paris—Commercial Club; O. T. Hinton, Secretary.

Scottsville—Commercial Club; J. D. Turner, President.

Stanford—Chamber of Commerce; J. C. McClary, President.

LOUISIANA

Alexandria—Chamber of Commerce, A. Wettermark, President.

Jennings—Chamber of Commerce, John Gamble, Vice-President.

Lake Charles and Calcasieu Parish Chamber of Commerce; Herbert Bayliss, General Secretary.

New Orleans—Louisiana Engineering Society, Samuel Young, President

MISSISSIPPI

Brookhaven—Board of Trade; W. H. Feavey, Secretary.

Canton—Young Men's Business Club, R. H. Powell, Secretary.

Columbia—Marion County Truck Growers' Association; N. R. Burkett, President.

Columbus—Chamber of Commerce; J. G. Weatherly, Manager.

Corinth—Business Men's Club; Geo. Hazard, President.

Greenville—Chamber of Commerce; R. L. Pritchard, Secretary.

In selecting the site for a government munitions plant perhaps the most important requirement aside from adequate hydro-electric power and its comparative safety from capture, is the variety and abundance of the minerals that are indispensable to warfare, within easy reach. With the enormous reserve of coal for coking purposes in close proximity to Muscle Shoals, with the limestone and coke for the making of cyanamide, with the bountiful supply of iron ore in great variety and the coke for its manufacture into pig iron, and with manganese, aluminum, zinc, copper and lead easily accessible, it appears that the advantages of Muscle Shoals can not be equalled anywhere else in the country.

DR. A. H. PURDUE,
State Geologist of Tennessee.
Nashville, Tennessee.

As I understand it, the requirements to be met in the selection of a site for government munitions plant are comparative safety from capture by the enemy and proximity to all the materials used in the manufacture of the various products, together with adequate hydro-electric power. There is probably no place in the United States where these conditions are so fully and adequately met as at Muscle Shoals on the Tennessee River in North Alabama. The Tennessee River furnishes the supply of water with sufficient fall to generate the required power. In close proximity to the Shoals are the quarries and mines to supply limestone, iron ores and coal in quantity sufficient for all demands for centuries. Ores of manganese, copper, lead, zinc and aluminum are also within easy reach. The level plains coming up to the river bluffs about the Muscle Shoals, are most admirable locations for manufacturing plants of various kinds, and of any desired magnitude.

EUGENE A. SMITH,
State Geologist of Alabama,
University, Alabama.

Greenwood—Business League; W. H. Hays, Secretary.

Gulfport—Service Club; T. J. Louther, Secretary.

Hattiesburg—Commercial Club; T. C. Hannah, President.

Houston—Progressive League; A. J. Dorman, President.

Iuka—Business Men's League; W. B. Ellis, President.

Meridian—Board of Trade and Cotton Exchange; A. H. Simpson, President.

Oxford—Business Men's Club; C. E. Sisk, President.

Starkville—Progressive Club; Will E. Ward, Secretary.

Vaiden—Business League; W. M. Armstrong, Secretary.

Water Valley—Water Valley Boosters' Club; Guy Neson, Secretary.

West Point—Merchants' Association; R. L. Betty, Secretary.

Wiggins—Progressive League; E. E. Bryan, President.

MISSOURI

Higginsville—Commercial Club; L. N. Shipley, Secretary.

NORTH CAROLINA

Charlotte—Engineering Society of the Carolinas; J. Frank Wilkes, President.

Southport—Commercial Association; C. L. Stevens, Secretary.

Wilson—Chamber of Commerce; C. E. Hope, Secretary.

OHIO

Galion—Chamber of Commerce; L. M. Vaughn, Secretary.

Lancaster—Chamber of Commerce; C. H. Sexauer, Secretary.

OKLAHOMA

Chickasha—Grady County Retail Merchants' Association; Arthur Ersland, Secretary.

TENNESSEE

Tennessee, State of—R. R. Sneed, Secretary of State.

Bristol—Board of Trade; J. D. Faucette, President.

Chattanooga—Chattanooga Engineers' Club; O. B. Agner, Vice-President.

Clarksville—Chamber of Commerce; P. J. Atkinson, Secretary.

Columbia—Board of Trade; A. B. Sowell, Secretary.

Cookeville—Commercial Club; J. W. Cooper, Secretary.

Decherd—Commercial Club; E. H. Ashcraft, Secretary.

Dyersburg—Business Men's Club; J. B. Carpenter, Secretary.

Humboldt—Business Men's Club; O. C. Sharp, President.

Jackson—Tennessee Rural Letter Carriers' Association; R. R. Randel, Secy.

Jackson—Merchants' and Manufacturers' Association; R. S. Fletcher, Jr., President.

Jellico—Board of Trade; R. Y. Moore, Chairman.

Knoxville—Tennessee State Florist Association; Karl P. Baum.

Knoxville—Board of Commerce; Joe Bowles, Secretary.

McMinnville—Commercial Club; W. H. Magness, President.

Memphis—Cotton States Merchants Association; R. R. Ellis, President.

Memphis—Rotary Club; R. W. Ramsey, Sr., President.

Morristown—Board of Trade; F. A. Witt, President.

Mt. Pleasant—Commercial Club; C. Y. Clarke, Secretary.

Murfreesboro—Board of Trade; R. W. Hale, President.

Nashville Section—American Chem. Society; W. H. Hollinshead, Chairman

Nashville—Commercial Club; R. B. Brannan, President.

Nashville Section—Engineering Association of the South; John Howe Peyton, President.

Nashville—Tennessee Academy of Science; Samuel M. Bain, President.

Newport—Commercial Club; J. A. Susong, President.

Pulaski—Business Men's Association; John T. Long, President.

Pulaski—Middle Tennessee Farmers' Institute; J. J. Zuccarello, Secretary.

Savannah—Business Men's League; A. W. Patterson, Vice-President.

Spring Hill—Farmers' Commercial Club; A. E. Greenlaw, President.

Tullahoma—Board of Trade; John W. Harton, Secretary.

Tullahoma—Middle Tennessee Editors' League; C. T. Crawford, President.

Winchester—Chamber of Commerce; H. B. Alexander, President.

TEXAS

Austin—Chamber of Commerce, Sam Sparks, President.

Corpus Christi—Commercial Club, E. N. Farris, Secretary.

Forney—Forney Commercial Club, O. E. Griffin, President.

Lubbock—Chamber of Commerce, M. S. Jacobs, Secretary.

New Braunfels—Citizen's League; Adolph Sedemann, Secretary.

Port Arthur—Board of Trade; W. H. Richardson, Secretary.

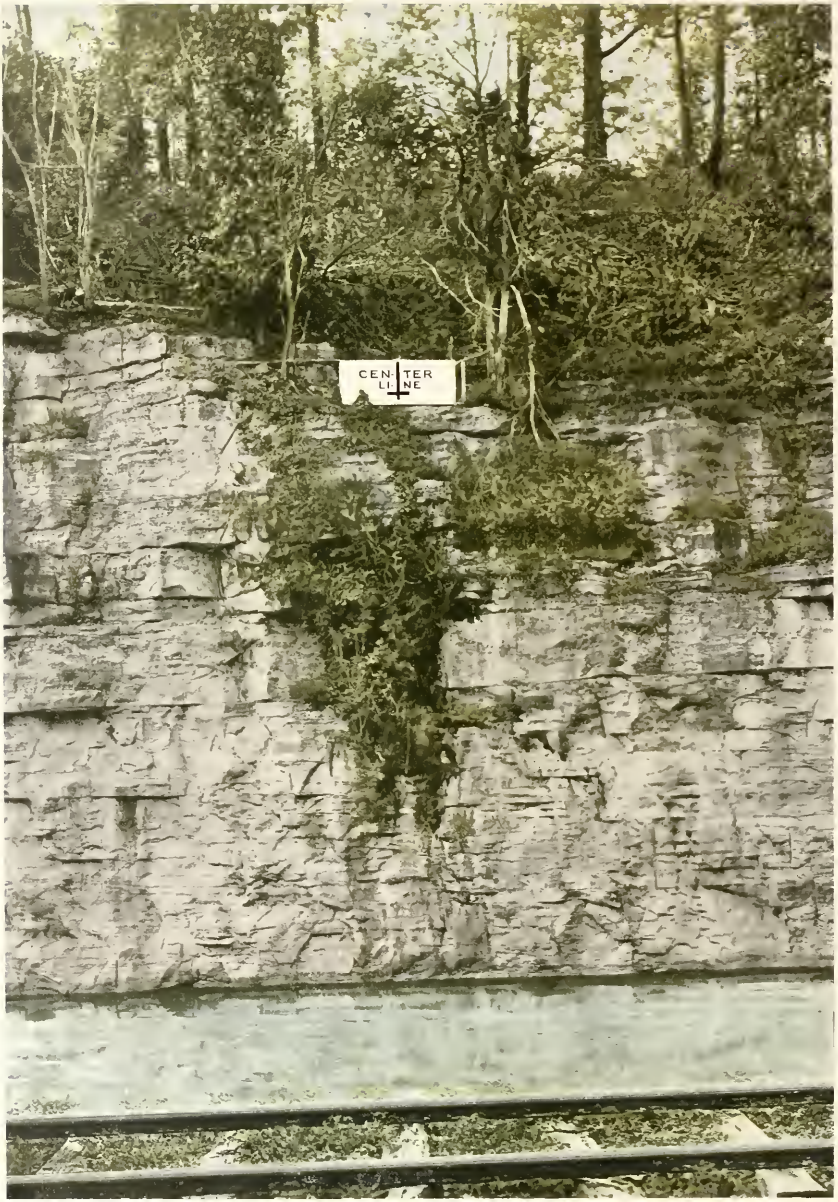
Yoakum—Commercial Club; J. M. Halle, Secretary.

VIRGINIA

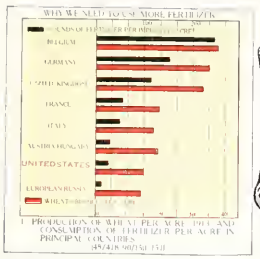
Charlottesville—Chamber of Commerce; W. R. Barksdale, President.

Lynchburg—Farmers' Educational and Co-operative Union of America, Virginia Division; A. B. Thornhill, President

Table of Contents



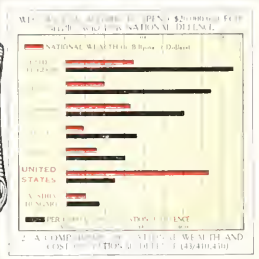
NORTH ABUTMENT DAM NUMBER THREE



1. PRODUCTION OF WHEAT PER ACRE, THE LAND CONSUMPTION OF FERTILIZER PER ACRE IN PRINCIPAL COUNTRIES

Part One

On This We Rest Our Case



2. A COMPARISON OF NATIONAL WEALTH AND COST OF WAR

What We Seek to Show

FIRST—*That a primary purpose of the section of the law appropriating $20,000,000 for a nitrate plant was to provide a full and dependable supply of cheap, high grade fertilizer* for increasing the crop production of the country, an increase that is sorely needed to reduce the high and ever rising cost of living. (Part Two)

SECOND—*That our nation, depending upon present resources, might be brought to serious straits in the event of war for lack of nitric acid for the manufacture of explosives;* and that Congress realized the necessity of providing for a definite, controllable supply of at least 180,000 tons of this acid annually in case of war, in addition to that produced to meet the normal and rapidly growing needs of the country. (Part Three)

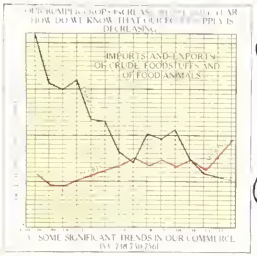
THIRD—*That these two essential developments in the fields of agriculture and military preparedness will carry with them another great public benefit, if the plants be worked out at Muscle Shoals, namely, the opening of the Tennessee River to modern navigation*—a long-delayed but inevitable improvement upon which there has already been expended millions of dollars, and the completion of which has been contemplated by Federal and State Governments for more than ninety years. (Part Four)

FOURTH—*That a true policy of conservation demands that we shall utilize the power of our running streams to extract the nitrogen that we need from the inexhaustible atmosphere; and that by-product ammonia has no place in so comprehensive a program,* for the reason that it is far too limited in quantity and much too high in price to bring to the country the great benefits in time of peace which were contemplated by Congress. And, moreover, it cannot be depended upon for a safe and sufficient supply of nitric acid in time of war. (Part Five)

FIFTH—*That Muscle Shoals on the Tennessee River offers the most suitable site for the plant* which is to afford a far-reaching benefit to the nation thru the production of a cheap effective fertilizer in time of peace, and an equally surpassing location for the plant which, thru the production of nitric acid for military use, is to become a national bulwark in time of war. (Parts Six and Seven)

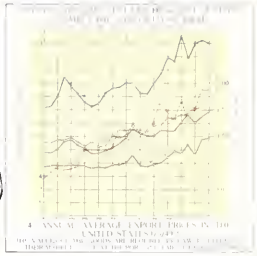
SIXTH—*That in all our broad land there is no other locality save the Central South which can offer to the nation's Chief Executive, who is to make the selection, the combination of the necessary safe and central site, the abundance of power, the wealth of closely associated resources, the proximity to commanding markets, the favorable climate, and the benefits to navigation which characterize the proposed location at Muscle Shoals.* (Part Eight)

POWER IN ABUNDANCE—THE TENNESSEE RIVER NEAR LOCK NINE.



Part Two

A Serious Situation and The Way Out



The Effect of a National Nitrate Plant on the High Cost of Living, and What it Will Do for the Farmer

OUR WASTEFUL FARMING

The past century has seen an industrial development in the United States that has no parallel in all history. The once insignificant colony struggling for existence amid unexplored forests has become the richest of the nations. (Diag. 2, p. 11)

Our forefathers found themselves in a land where the natural resources could scarcely be measured. With courage and enterprise that won the admiration of the world they applied themselves to the task of utilizing the vast natural wealth, taking only the best at hand, and wasting all else, for was there not enough and to spare? So we find that only the richest lands were cultivated, and as the soils lost their fertility the farmers merely contented themselves with reduced returns, or moved to new locations.

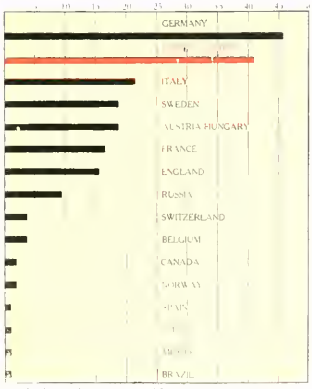
The consequences of this utter wastefulness have become painfully evident.

WORLD STARVATION AND REMEDY

As early as 1898 Sir William Crookes, then President of the British Association for the Advancement of Science, pointed out to the Association (1) that the world's food consumption was running beyond the capacity of the cultivated lands producing it. He expressed the conviction that the only way in which world starvation could be averted, the sole sufficient means of increasing the yield of the world's cultivated acres, would be found in the universal use of a bountiful supply of fertilizer containing that most valuable element, *nitrogen*.

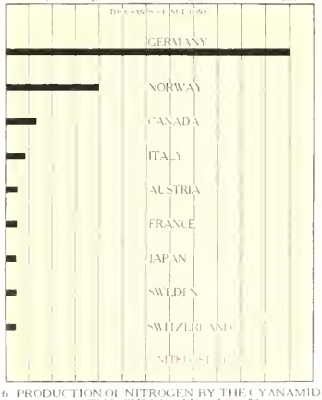
Every progressive farmer knows that the fertility of his soil depends upon the phosphoric acid and potash, and in an overwhelming measure, upon the nitrogen it contains. He knows that should the supply of this nitrogen become too greatly reduced the best of soils will not repay its cultivation, while the utter lack of nitrogen would soon reduce to a barren waste a soil which in other respects might be most favored.

Here in America after years of careless agriculture on fertile lands, with virgin fields to be had in abundance, we find that we have robbed our soils of the nitrogen that only countless centuries can restore by natural processes.



6. ELECTRIC FURNACES IN OPERATION AND BUILDING, JANUARY, 1915 (81, 94, 95)

Have we, then, adopted an adequate artificial means of restoring to our soils this indispensable element? Far from it. Four-fifths of every breath we draw and a large part of our daily food is nitrogen. Above every seven acres is as much of this element as the world consumes in a year in the form of saltpeter, the principal commercial form of nitrogen ( ). *Yet in all the United States, with its wealth of waterpower and host of electric furnaces*



6. PRODUCTION OF NITROGEN BY THE CYANAMID (ATMOSPHERIC) PROCESS (72)

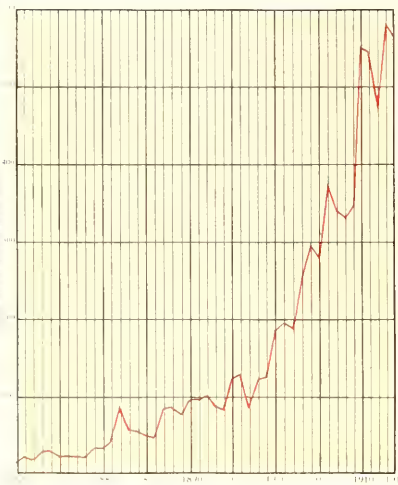
there is nowhere a factory for taking from the atmosphere a single pound of this measureless supply and making possible its restoration to our hard-taxed soil. (Diags. 5 and 6, p. 13)

Moreover, through modern achievement in the cure and prevention of disease and our rapid progress of knowledge in sanitation and domestic science we have reached a point where but 65 years are required to double our population (51/4).

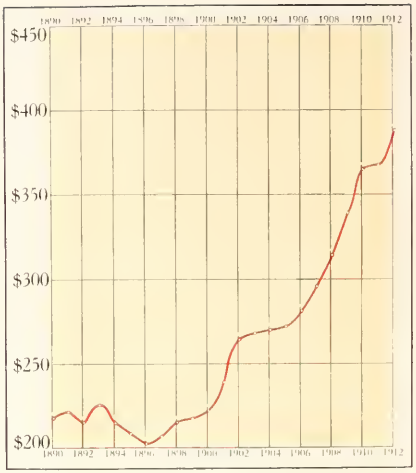
With this rapid increase of our population, and the consequent increasing demand for food production, we are becoming more and more dependent upon outside markets. (Diag. 3, p. 13) From 1900 to 1910 our imports of food and animals practically doubled and our imports of manufactured foodstuffs more than doubled. Our exports of wheat and flour fell from 31 per cent of the total production to only 13 per cent, while our production of beef cattle has decreased 32 per cent in 14 years (50 4).

THE RECKONING IN AMERICA

A serious reckoning is fast approaching. In ten years, 1900 to 1910, our population increased 21 per cent while our crops increased but 10 per cent (50 4), and the resulting high cost of living is felt from coast to coast. (Diag. 4, p. 13) Food which could be bought for 55 cents in 1896 increased in cost to one dollar, or 80%, in 1912 and living expenses which at the beginning of this period could be met by 63 cents, at its end required a full dollar, an increase of 60% (50 4). (Diag. 8, p. 14) From 1896 to 1912 the average increase in the cost of living per year was 5 per cent, but from 1912 to 1914 the average annual increase was 7 1/2 per cent (50 4).



7. OUR INCREASING CONSUMPTION OF CHILEAN NITRATE (73)



8 APPROXIMATE COST OF A YEAR'S FOOD SUPPLY TO AN AVERAGE WORKINGMAN'S FAMILY IN THE SOUTH CENTRAL STATES AT THE AVERAGE PRICES FOR EACH YEAR, COMPILED BY U. S. BUREAU OF LABOR (39 35)

It should be noted that in discussing the high cost of living we do not consider the sharp advances in prices which have occurred since the beginning of the European war, since the condition created is far from normal, but let us examine these advances for a moment:

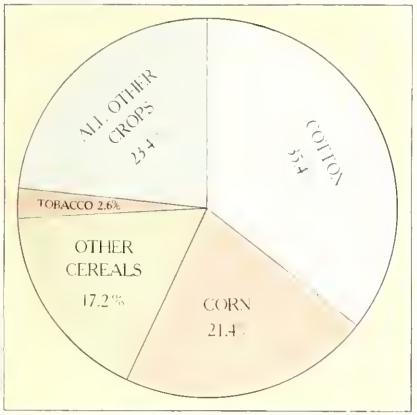
The following table, compiled by the U. S. Bureau of Labor Statistics, shows the increase in prices of the past few months in Washington, D. C.:

Article	*1890*	*Apr. 1915*	*Oct. 1916*
Round Steak	.126	.27	.301
Pork Chops	.10	.22	.25
Ham	.138	.19	.244
Lard	.103	.13	.20
Flour (1-8 bbl.)	.951	1.25	1.36
Potatoes	.271	.35	.43
Eggs	.232	.40	.45
Butter	.31	.38	.434
Sugar	.06	.065	.077

(From the *Washington Times*, Nov. 24, 1916.)

THE WAY OUT— CHEAP FERTILIZER

As stated by Sir William Crookes, the way out of the difficulty lies in the increase in crop yields per acre (Diag. 10, p. 15) cultivated without additional labor (77). One means alone is known for accomplishing this the use of sufficient nitrogen, supplemented by the other principal plant foods, phosphoric acid and potash, making a complete fertilizer, in which the most expensive (40 19) and important element is nitrogen. (Diag. 12, p. 17)



9 Division of Fertilizer Consumption Among the Principal Crops of the U. S (90 75)

To accomplish the needed results, the fertilizer must be cheap, so cheap that the farmer can use it bountifully and with a profit of one hundred to two hundred per cent on its cost, whether he be located in the great wheat belt of the northwest, in the potato country of Maine, or in the corn and cotton sections of the central and southern states.

SOURCES OF NITROGENOUS FERTILIZER

Our principal sources of nitrogenous fertilizer materials are three in number: First, there is cotton seed, which constitutes the source of one-half of our supply of nitrogen for fertilizers [illegible]. The utter wastefulness of using this valuable feedstuff as a fertilizer is condemned in no uncertain terms by Mr. Tate Butler, Editor of the *Progressive Farmer*, who says:

> "As a general principle, it may be laid down to be adhered to in most cases, that any product which is not suitable food for men but good feed for livestock should not be sold off the farm. Nor should any product suitable for feeding livestock be used as a fertilizer direct, as a general farm practice" [illegible].

Mr. Butler then shows conclusively that while one ton of cotton-seed meal has a market value of but $30.00 when sold as a fertilizer, it has a combined feeding and fertilizer value of $62.50 per ton when used as feed for cattle.

The second source of nitrogen supply, namely, the ammonia secured as a so-called "by-product" from the manufacture of coke, is disqualified by its own champions as an adequate source of cheap fertilizer (Part 5).

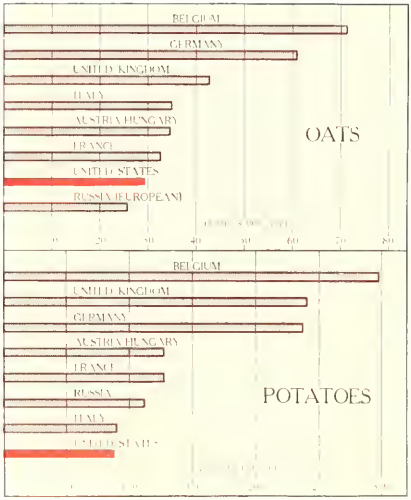
The third source of nitrogen gives assurance of meeting the demands of the situation in every particular. This source is the free nitrogen of the atmosphere, "fixed" or made available by an electro-chemical process which takes it from the air and places it in lime, or other materials so that it can be used.

FIXATION of ATMOSPHERIC NITROGEN

Here is an industry built up by fifteen years of scientific research which offers to the farmer the cheap fertilizer which he so much needs to increase food supply and reduce its high cost. And we of the United States, chief among nitrogen paupers, struggling with inadequate crop yields and rising prices for food, are, save one, the only great modern nation which has failed to seize this beneficent offering of science and turn it to account for the welfare of our people. (Diag. 6, p. 13) Germany, Italy, England, France, Norway, Sweden, Austria, Canada and Japan have established large factories for taking their nitrogen from the atmosphere and have devoted a million continuous horsepower solely to this one industry [illegible]. Germany alone, since the beginning of the war, has developed an air-nitrogen industry requiring 300,000 continuous 24-hour horsepower at a cost of more than a hundred million dollars. As a result of this notable enterprise she is independent today of all outside sources of nitrogen and will apparently continue so throughout all time [illegible].

U. S. NOT IN FERTILIZER BUSINESS

The plan of Congress is not without opposition on the part of certain politicians and self-centered interests. They declare that it is socialistic and that it brings the government into commercial business in competition with private concerns.



10 Crop Production Per Acre in the Principal Countries of the World, 1913 (48, 430, 454)

The charge is without foundation. The government has no idea of entering into trade. It is simply doing what the government alone can do—making possible the production of fertilizer on a sufficient scale and at a price low enough to enable the farmer to make profitable the use of fertilizer, in which at present, with certain crops, he finds little or no profit, or even risks a loss by its use.

To extract great supplies of nitrogen from the atmosphere a large amount of very cheap power is needed—so cheap that it must be had for less than ten dollars per horsepower per year [16 11] or from one-third to one-fourth of what it costs a large steam plant to produce it. If sufficient fertilizer is to be supplied, so that the plant may become an effective factor in the situation, then 200,000 horsepower must be available for 90 per cent of the time [30 15].

CALCIUM CYANAMID AS A FERTILIZER FOR MUSTARD

CALCIUM CYANAMID AS A FERTILIZER FOR OATS

To produce this amount of electrical energy at such a low rate we must rely upon water-power, for it is a well known fact that no steam or gas plant, however favorably located, could produce power at costs even approaching such a figure, and to adopt such a measure would mean a heavy and entirely unnecessary draft upon our coal supplies.

WHY U.S. SHOULD BUILD PLANT

The establishment of such a hydro-electric plant is properly to be undertaken by the Government, not only because of the great national need that it will supply, but also because of the large investment necessary. While a first-class steam-electric plant may be built in normal times in most locations for, say, $50 per horsepower, the waterpower plant, with its huge dam and acres of overflowed lands, costs upward of $100 per horsepower [16 11]. The physical operation of a large waterpower plant is not expensive (being only about $2 per horsepower per year), but the interest and sinking fund charge upon the investment is a large item, as it represents about 80 per cent of the cost of hydro-electric power when developed by private interests. (Diag. 11, p. 17)

So, other things being equal, *he who can borrow money at the lowest rate can sell power the cheapest*, and the production of cheap hydro-electric power is seen to be chiefly a problem in financing, rather than one in engineering.

The party preeminent as a borrower at low rates is our Uncle Sam. A private individual in building up a new plant involving the risks attending a hydro-electric installation must pay 10 per cent for interest and sinking fund charges while our Government need pay but 4 per cent for these items [46 17].

In Canada, near Lake St. John, there are magnificent power sites, and a million horsepower can be developed there, the first three hundred thousand of which, according to engineers' estimates, need not cost over $40 per horsepower [30 17].

Suppose a private individual develops a Canadian power site. His interest and sinking fund expense per annual horsepower must be 10 per cent of $40 or $4, added to which will be $2 for operation, making his total cost $6 for each horsepower per year.

Now suppose that Uncle Sam undertakes to secure power at a site in the United States which costs, say, $100 per horsepower for its development. His interest and sinking fund expense will be but 4 per cent of $100 or $4 per annual horsepower, and his operating expense $2 making his total cost $6 for each horsepower per year. That is to say that although his investment is much greater, his cost per annual horsepower will be no greater than that of the Canadian plant.

In other words, our Government through its power to borrow money at low rates can, in effect, bring into the United States the splendid Canadian power sites with their superior possibilities for producing electrical energy at low cost.

—Courtesy Harper & Bros., N.Y.

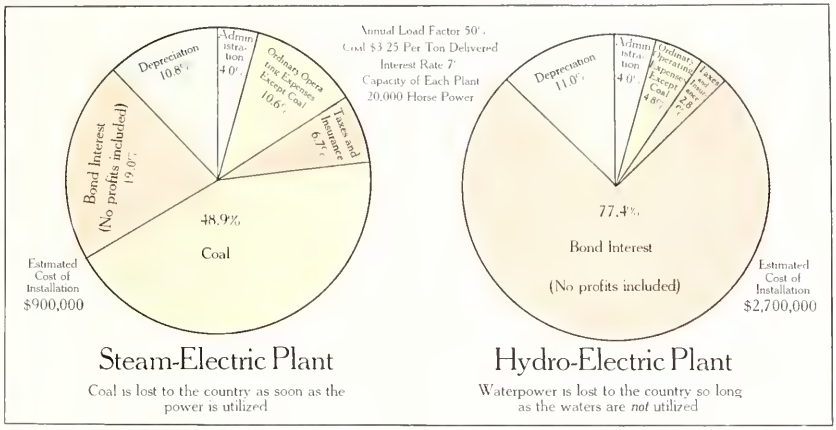
AN INTERESTING EXPERIMENT IN THE FERTILIZATION OF POTATOES

And this is just what is needed by the farmer. For the law provides that the President may sell the surplus products of the nitrate plant, chief among which would be electric power; and private capital under Government supervision can take this cheap power in time of peace and convert it into a cheap effective fertilizer by combining fixed nitrogen and phosphate rock, producing a material that is 60 per cent plant food [48 11].

And finally, an important advantage in this plan is seen in the fact that by securing our fertilizer and our nitric acid in this manner, *we have added this much to the resources of our country* and have not simply diverted a material already in use for other purposes, to the detriment of other interests, in order that these great ends may be served.

QUALIFICATIONS OF MOST SUITABLE SITE

What then, are the demands made by the economic situation upon the site which shall claim to be the proper location for such a



11. A Comparison of Operating Expenses of a Steam and Hydro-Electric Power Plant of Same Capacity (74 585, 590)

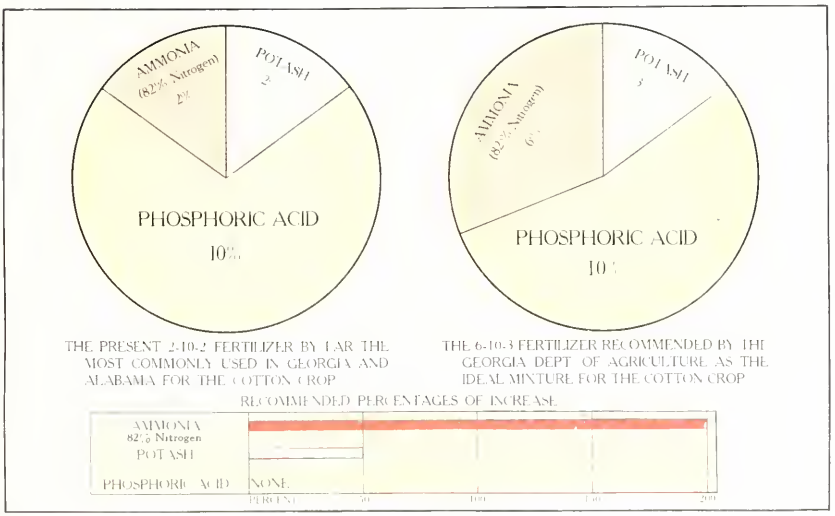
fertilizer plant? As a foremost requisite, it must afford ultimately not less than 200,000 horsepower available 90 per cent of the time (90 [illegible]) and costing not more than $5 to $10 per horsepower per year (46 [illegible]).

The necessary raw materials, such as limestone, coke and phosphate rock (4[illegible]) in quantities practically without limit, must be available within easy reach, and the site should be centrally located with respect to the great fertilizer consuming sections of the country, the greater part of which are devoted to cotton and corn, (Diag. 9, p. 15) so that the average transportation charges on the product would be a minimum.

It should have the advantage of a mild climate with its freedom from ice and there should also be no lack of that cheap contented labor to be found where living is cheaper than in the more rigorous latitudes.

At first view it might seem wholly impossible to find a great power site capable of meeting such an array of requirements. But our country is truly fortunate in possessing such a site, favored above all others in the requisites for such an undertaking.

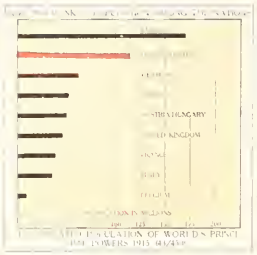
But that, as Kipling has said, is another story.

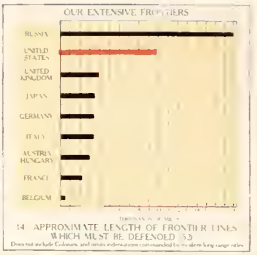


12. Practical and Ideal Fertilizers for Cotton. Why We Need More Nitrogen (34 34)

Part Three

Our Powderless Prowess





The Military Situation and Uncle Sam's Nitrate Plant

AMERICA'S SERIOUS PLIGHT

The largest publisher in the world is the Congress of the United States [illegible]. In addition to publishing thousands of books, reports and pamphlets, the proceedings in the various sessions of the Senate or House, and in the many hearings before the committees of Congress, are printed, word for word.

But there was one publication, an account of a hearing before the Committee on Military Affairs of the Sixty-third Congress, Second Session, for which an interested public waited in vain—it was never printed [illegible].

Reasons enough, there were, for suppressing its publication, for on that day, before the Investigating Committee, no less an authority than Brig.-Gen. William Crozier, Chief of the Bureau of Ordnance, U. S. Army, presented testimony both startling and alarming.

What he said was given in confidence, but today it is a well known fact that at the time of that hearing there was in all America sufficient powder for but two and one-half hours' fighting as it is done today [illegible].

The most serious phase of the situation lay in the fact that we have no adequate source of raw material for making our own explosives, but are obliged to import the principal fundamental requirement nitrate of soda, the source of the necessary nitrogen from Chile [illegible]. (Diag. 7, p. 14) When we observe the astonishing changes that a few months' time has wrought in the world's most civilized countries, it is not surprising that grave apprehension was aroused concerning our powder situation.

Preparations to increase our imports of nitrate were quickly undertaken. Appropriations were made for the erection of storehouses and for the accumulation of a reserve supply of 32,500 tons of the indispensable nitrate, and in July, 1914, we were said to have some 20,000 to 25,000 tons on hand, altho it was stated that five years' time would be required to complete our supply [illegible].

And such a pitiable supply it is! Germany at the beginning of the war had, not twice this amount, but *twenty times* as much, and exhausted it completely within a few months [illegible]. So grave is the situation that a prominent member of the Naval Consulting Board is credited with the statement that—

> "The lack of nitric acid, the indispensable chemical in the manufacture of smokeless powder and high explosives, would cause the United States to be defeated in less than a year after war started with a first-class power, unless our navy was more powerful than that of the enemy" [illegible].

DEMANDS OF MODERN WARFARE FOR EXPLOSIVES

Modern warfare calls for powder and explosives on a scale without a parallel. Before an infantry attack the ground must be "prepared" not merely by shelling the enemy's position with single shots, or at best, salvos of carefully timed shells from a small battery as in the War of 1861-65, but by a torrent of steel that must sweep the field as

Copper Smelter and Sulphuric Acid Plant, Tennessee Copper Co., Copper Hill, Tenn

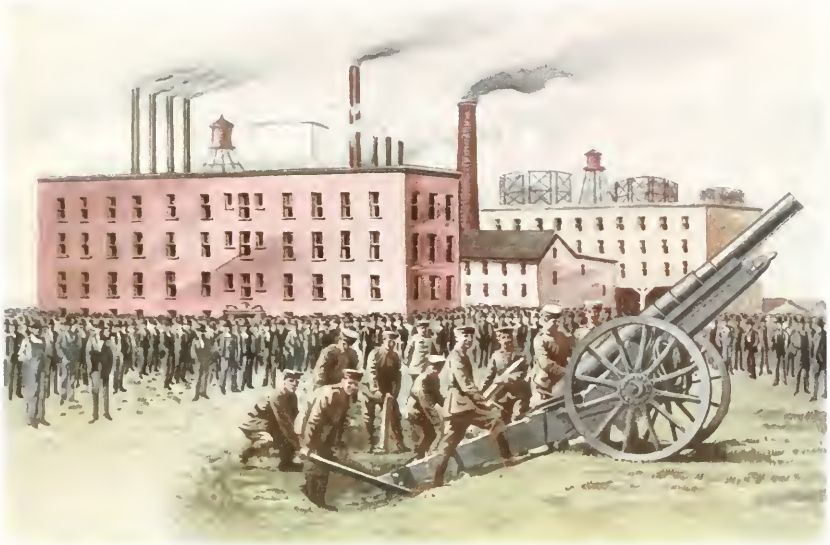
a solid sheet, plowing the enemy's trenches to the underlying rock and wrecking safety pits thirty feet below the ground. For, on most excellent authority [90, 91] we know that the 40-centimeter (16-inch) shells in use today penetrate the ground and explode with such terrific force that a crater thirty feet deep and fifty feet in diameter is often formed, while men are buried alive by the score beneath the avalanche of falling earth.

It is needless to remark that the consumption of high explosives in this orgy of death and destruction is stupendous—no less than a hundred times as great as in any previous conflict in history.

As to their comparative values Brig.-Gen. Crozier, Chief of Ordnance, U. S. Army, testified before a committee of Congress [SEE [7]] as follows:

"There are two ways of getting nitric acid independently of an outside source of supply. One is by the use of ammonia, which is one of the by-products of coke making, gotten from coke ovens. That, I think, would give a limited source of supply. I am not able to say the extent to which we could rely on that. It has never been relied on at all in this country. It is chemically possible to produce it in this way, and there is a good deal of the coke-making industry in this country.

"The best reliance which I think could be had would be upon the fixation of atmospheric nitrogen which is now being done in several countries abroad and which requires a very considerable amount of cheap electric power, so cheap in order to compete with the imported nitrate, that it can only be had now by the use of abundant water power."[*]



15. A Modern Rapid-Firing Gun With Crew of Ten Men and the Modern Factory and Force of Five Hundred Mechanics Needed to Keep It Supplied With Ammunition for Operation at Full Capacity (91)

Based upon estimates of our War Department, Germany's bill for powder alone soon after the outbreak of the war amounted to $1,000,000 per day [91, 92] and when we remember that all Germany could be readily placed within our single state of Texas, the possible requirements for the defense of our 11,000 miles of coast line and border fronts are not reassuring, to say nothing of our remote lock-canal and oversea possessions. (Diag. 14, p. 18)

THE TWO SOURCES OF NITROGEN

There are but two recognized sources of nitrogen for powder manufacture that are known to be commercially available within our boundaries the by-product ammonia resulting from the manufacture of coke from coal, and the free nitrogen of the atmosphere.

To depend upon the by-product of any single industry to meet the country's powder requirements in time of war would be the utmost folly, and in a later discussion we will attempt to point out the dangerous fallacy of placing reliance in by-product coke ovens for this enormous supply of nitrogen for explosives. The wording of the National Defense Act itself would indicate that Congress realizes to the fullest extent that the one great adequate source of nitrogen is the atmosphere which surrounds us.

[*] The italics are ours

ECONOMY OF THE PLAN OF CONGRESS

By making use of the atmosphere under the plan now before the President a large and important advantage is to be gained. The country can secure the facilities of a $42,000,000 nitric acid plant at a cost of but $20,000,000 since the $22,000,000 plant to be built for the manufacture of fertilizer can be converted into a plant for the manufacture of ammonia gas for use in making nitric acid by the simple turning of a valve (46 39). The Government, therefore, will need only the necessary plant to complete the final step of the process, namely, the oxidizing of the ammonia gas into nitric acid. Under this arrangement the Government's investment would be—

Dam, locks and power house	$12,000,000
Nitric acid plant	8,000,000
Total	$20,000,000

In this way the Government can meet its needs, owning and operating its own plant and having no relations with outside parties other than the common one of buyer and seller.

FIXING LOCATION of NITRIC ACID PLANT

And where should we locate this great plant, requiring as it does 120,000 continuous horsepower (55 6) in time of war for the production from the atmosphere of this 180,000 tons of nitric acid—two-thirds of the consumption of Germany at the beginning of the war—estimated as the amount needed by our army and navy? (55 3)

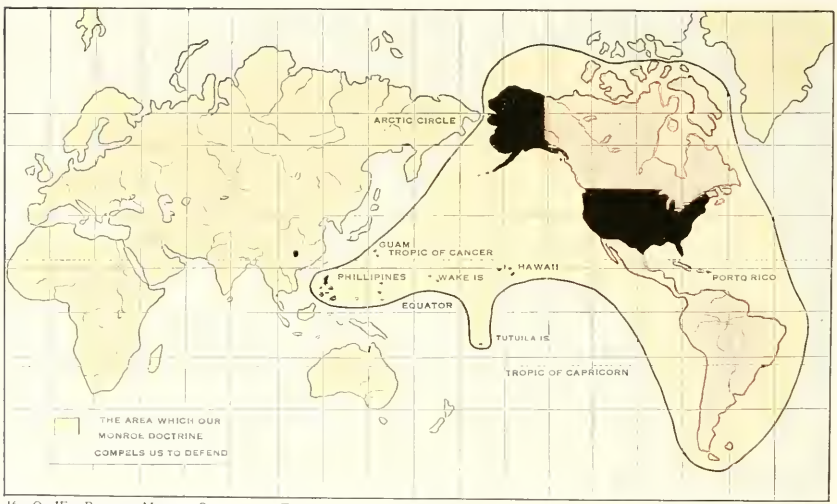
*The italics are ours.

ICE JAM AT KEOKUK, IA., POWER PLANT. ICE NEVER FORMS ON THE TENNESSEE RIVER AT MUSCLE SHOALS

The first consideration is the clear pronouncement of the War College (1915 Bul. 2, Sec. 60):

"*As a general military principle no supply depot, arsenal nor manufacturing plant of any considerable size supported by War Department appropriations for military purposes, should be established or maintained east of the Appalachian Mountains, west of the Cascade or Sierra Nevada Mountains nor within 200 miles of our Canadian or Mexican borders and steps should be taken gradually to cause to be moved depots and manufacturing plants already established in violation of this military principle.*"* (See Appendix Map at back of booklet.)

Here then is the chief of our fundamental requirements dictated by the law of self-protection, often worded "Safety First." We believe that no power

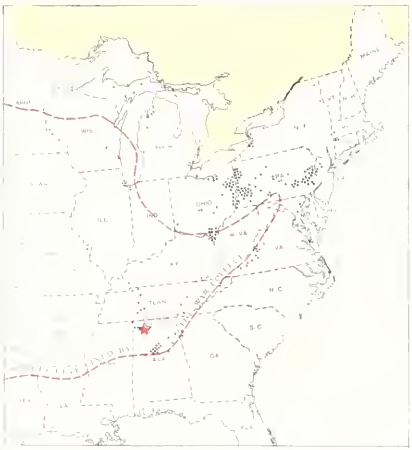


16 OUR FAR-REACHING MILITARY OBLIGATIONS. THE AREA WHICH THE MONROE DOCTRINE COMPELS US TO DEFEND (42, 60) *Courtesy Hudson Maxim*

site, however attractive in other ways, located outside the limits of the safety zone thus clearly established, would command the President's serious consideration; for not only must our plant lie far beyond the range of the guns of a possible enemy, but it should be located in a region naturally protected from invasion and distantly removed from possible enemy aërostations.

The map at back of booklet shows the safety line of the War College with reference to the location of the country's principal streams, its natural resources, and its Government arsenals and munition plants. Notice how few of the large power streams lie within the safety zone. (See also Map 31, pp. 39, 40)

A second demand made by the requirements of the military situation is that the location shall be reasonably central. The tremendous difficulties attending the protection of thousands of miles of transportation lines needed to haul the Government's nitric acid, and the unreasonable cost of bringing all of this dangerous acid from a remote corner of the country make figures unnecessary in support of the contention that, other



17. Location of American Fixed Fuel Plants in 1909 (27 428)

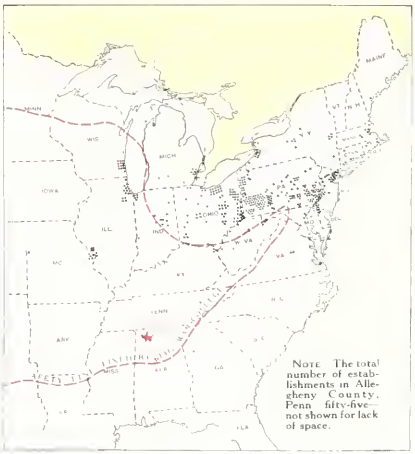
things being equal, that site is the most suitable which is in closest touch with the Government's centers of distribution of war munitions, and which possesses the lowest transportation rates.

A third essential is found in the fact that this plant will require approximately 120,000 horsepower (90 000) which may be required continuously day and night at any time, and for an indefinite period, to produce annually at least 180,000 tons of nitric acid.

A fourth requirement calls for a plentiful supply of necessary raw materials within easy reach. Just what these essentials would be would depend, of course, upon the process used. It is likely that a bountiful supply of pure, high-grade limestone and a good grade of coking coal, together with an abundance of pure water would be primary requisites.

As a fifth condition, since the making of munitions is a companion industry to the nitrate plant, it is desirable that sufficient power and the necessary raw materials for the manufacture of munitions of war shall be readily available.

And finally, for the making of nitric acid for explosives no less than for the manufacture of fertilizer there would be required those favorable conditions



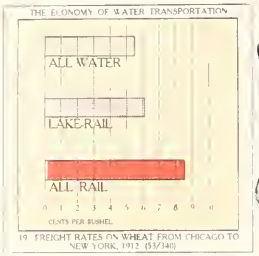
18. Location of American Steel Works and Rolling Mills 1909 (37 430)

respecting labor and climate, to which reference has already been made in a former chapter, with the added desirable condition that the local population shall be native American, as free from any foreign element as possible.

As was seen in the case of the situation for the fertilizer plant, it would seem difficult if not impossible to find a location not barred by these formidable requirements, in this land of unfavorable power sites.

But we are doubly fortunate, for centering about the site that is the ideal location for the production of cheap fertilizer, we find every raw material necessary for the making of nitric acid in time of war—and not materials for the acid alone but for the whole gamut of military requirements from the steel for great siege guns down to the aluminum for the soldiers' drinking cups.

In chapters that follow (Parts 6 and 7) we briefly describe some of the principal resources of that great valley of natural riches christened affectionately by its people "The Dimple of the Universe."



19. FREIGHT RATES ON WHEAT FROM CHICAGO TO NEW YORK, 1912. (53/340)

Part Four

New Light on an Old Subject

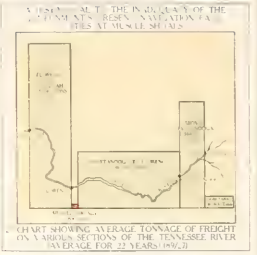


CHART SHOWING AVERAGE TONNAGE OF FREIGHT ON VARIOUS SECTIONS OF THE TENNESSEE RIVER (AVERAGE FOR 22 YEARS 1892-3)

Navigation on the Tennessee River and What the Development of Muscle Shoals Will Do For It

EFFORTS OF THE PAST

If a county should build a stretch of level highway of the best material, expending a large sum in its construction, and fail to improve a few steep hills over which only the lightest loads could be drawn, such procedure would closely resemble that of the State and National Governments in their efforts to improve the Tennessee River for navigation by the canalization at Muscle Shoals.

As a chain is no stronger than its weakest link, so a river is no more navigable than its shallowest stretch. It was in strange disregard of this simple fact that the State of Alabama in 1831–1836, assisted by the United States Government, built the first Muscle Shoals Canal. Congress granted 400,000 acres of public lands to the State of Alabama, the proceeds from the sale of which were to be applied principally to the improvement of Muscle Shoals and of Colbert Shoals.

Although canals around Elk River Shoals, Little Muscle Shoals, Nance's Reef and Muscle Shoals proper were needed, only the latter waterway was constructed. It contained 17 locks each 120 ft. long by 32 ft. wide and each having a "lift" of almost 5 ft.

But as the canal could be reached only by craft which could pass the shoals above it, which were still unimproved, it was but little used and was abandoned in 1837.

No appropriation having been made for its maintenance it fell into ruin. The wooden gates with which the locks were equipped soon decayed, rains and floods played havoc with the embankments, and


Canal and River at Muscle Shoals, Showing Government Railroad Used in Maintenance Work

the channel filled with mud, supporting a flourishing growth of willows and cottonwoods.

Such was its condition in 1871 when, recognizing the importance of opening the Tennessee River to navigation, the Federal Government caused surveys to be made for its reconstruction, providing a canal $14\frac{1}{2}$ miles long with 9 locks, having a combined "lift" of 85 ft. At the same time a canal $1\frac{1}{2}$ miles

THE SMALL RIVER STEAMER FOR WHICH THE PRESENT MUSCLE SHOALS CANAL IS ADAPTED
THIS TYPE OF CRAFT PASSES THRU CANAL IN $11\frac{1}{2}$ HOURS (71)

long with two locks was planned for Elk River Shoals, 8 miles upstream, but Nances Reef and Little Muscle Shoals were not provided for at all. The building of the two waterways, known as the Muscle Shoals Canal, was begun in 1875 and only partially completed in 1890 [illegible] but the full work as planned has never been carried out.

The Muscle Shoals Canal (Photos, pp. 22, 24, 25 and 50) was planned before the days of powerful tug boats and their huge consorts of barges. It is adapted to the typical river steamer of light draft. (Photo. p. 23) which can make the eleven lockages and pass the canal in about $11\frac{1}{2}$ hours during periods of high water [illegible].

A fleet of 60 coal barges and tug such as is in daily use on the Ohio. (Photo. p. 23) would require 671 separate lockages, and ordinarily, would not be able to cover the 24-mile stretch at Muscle Shoals in less than 28 days, 18 hours, provided the water remained at a stage sufficiently high to permit navigation at all (71). It is needless to add that the canal was not designed to accommodate this class of navigation.

Small wonder, then, is it that the traffic through the canal averages only 11,800 tons per year, while hundreds of thousands of tons move on the river above and below it! (Diag. 20, p. 22)

OPENING AN INLAND EMPIRE

Penetrating as it does into the very heart of the richest undeveloped region in America, the Tennessee River forms the natural outlet for heavy freight in great variety. In this region we find, in the words of the late Senator Morgan:

> " * * * vast areas of the most productive soils, yielding enormous crops of food, cereals and textiles, fruits and grapes; and forests that are almost primeval and include all the varieties of trees that grow in the Temperate Zones; vast beds of coal and of iron, zinc, lead and copper ores, and rich veins of gold; great quarries of marble that excel those of Italy in texture and in the varieties of beautiful coloring, and all of the slates and rocks that are useful and beautiful in architecture, while the hills are crowned with the plumes of stately pine forests that never fade nor fall" [illegible].

THE TUG AND RAFT OF BARGES IN USE ON THE OHIO RIVER FOR WHICH THE PRESENT MUSCLE SHOALS CANAL SHOULD BE ADAPTED
THIS TYPE OF CRAFT WOULD REQUIRE 28 DAYS, 18 HOURS FOR PASSING THRU CANAL (71)

More than 13,000 miles of navigable streams spread as a network over the great central valleys of the United States and form the most extensive and important body of navigable waters in the world [illegible] (Map 22, p. 26). On their banks are thriving cities and towns numbered by the thousands, but these markets, so cheaply reached from Ohio River points, are effectively shut off from the upper Tennessee and its rich territory by the rapids at Muscle Shoals.

PANORAMA OF TENNESSEE RIVER

The necessity for adequate navigation structures at these shoals is not to be measured by the two million tons of freight valued at fifty million dollars, which move on the Tennessee River annually. Far less is it to be measured by the 12,000 tons which annually make their way through the inadequate canal.

Were our suburban electric lines, carrying their millions of passengers daily, constructed because millions of persons living in outlying districts demanded that these lines be built?

Does a modern railway system extend its line into a vast wilderness because of the large volume of freight coming out of that wilderness by wagon?

Of course not. Public carriers develop their traffic after their lines have been constructed into territories where possibilities of traffic exist. Business is found where the best service at least cost is offered. To this well-known economic principle our river transportation offers no exception. Would our Government develop a great commerce on the Tennessee River where the possibilities are so great? Then proper facilities must be provided. We can no more expect to develop commerce and call into useful service the dormant wealth of the upper Tennessee Valley while using the present forty-five-year-old canal facilities at Muscle Shoals, than can a modern railroad system expect to grow and thrive while continuing to operate with 50-lb. rails and the diminutive cars and wood-burning locomotives of 1870.

And commerce will not come to the river, and attempt to make use of navigation facilities that do not exist, any more than people will flock to the suburbs and build homes before a means of suitable transportation is provided. We must make commerce practicable along modern lines before we can expect to have it.

PRIVATE IMPROVEMENTS

Recognizing these well-known facts, the people have met the Government far more than half-way. Where in America has private enterprise expended more for navigation improvements than has been appropriated by the Government? Yet such is the case on the Tennessee River. Second only to Muscle Shoals, the rapids at Hales Bar had long been an impassable obstacle to navigation. Citizens of Chattanooga improved Hales Bar for power and navigation at a cost of over $11,000,000, practically without expense to the Government. (Photo, p. 53)

ONE OF THE SHARP CURVES—MUSCLE SHOALS CANAL

AT SITE OF DAM NUMBER TWO

This important benefit to navigation leaves only Muscle Shoals to be eliminated to make the Tennessee navigable to its mouth; and the great dam at Hales Bar, deprived of its real value to navigation so long as Muscle Shoals remains unimproved, stands as a challenge to our Government to meet its citizens half-way and provide the facilities which will enable Hales Bar Dam to render in full measure the service for which it was built.

THE SHORTER WATER ROUTE

The Ohio and Tennessee are twin streams in many ways. They rise close together in the same range of mountains and their upper tributaries flow thru the same coal and iron fields, and thru the same vast forests. The streams are similar in that they are of equal volume at Paducah, Ky., where they unite, while the volume of the flow in the Tennessee River at Knoxville is twice as great as that of the Ohio at Pittsburgh. It is therefore evident, that, from an engineering standpoint, the 9 ft. channel provided for the Ohio River is practicable for Tennessee River also (7, 15, 21). (Diag. 21, p. 25)

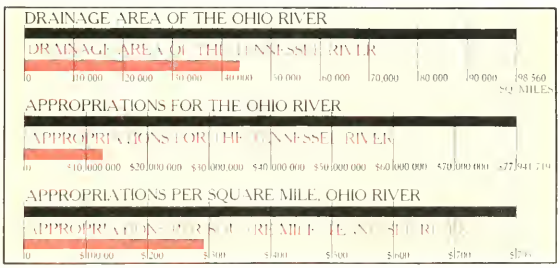
The distance from these important mines, forests and agricultural districts to any of the thousands of river points west of Paducah, is shorter by way of the Tennessee and Cumberland Rivers than via the Ohio River by several hundred miles (7, Appendix E).

But these facts have long been known, and we mention them here simply to point out the significance from a standpoint of navigation interests, that attaches to the improvement of Muscle Shoals.

The Board of Engineer officers directed "to consider and report on combined improvement of the Tennessee River at Muscle Shoals for navigation and water power development" reported that the cost of the improvement at Muscle Shoals properly chargeable to navigation had been estimated at $8,575,000, and stated that—

OFFICIAL VIEW OF SITUATION

"The existing commerce of the section as well as the increase which might reasonably be expected apart from what may be created as a result of the power development, is insufficient to justify so great an expenditure for improvements for navigation alone. But, in determining the worthiness of the project, there are other criteria that should be considered. It is known that the section of the United States lying within a moderate distance of the Muscle Shoals reach of the Tennessee, is in a state of retarded development. It is endowed with mineral, forest and agricultural resources which, when fully exploited, will add greatly to the general prosperity. It is the belief and expectation of those interested in this project that the development and utilization of the power now wasting in the Tennessee River will cause the establishment of manufacturing industries which will utilize the raw materials found in the immediate vicinity.



21. THE PRINCE AND THE PAUPER (89-A 5, 67 15, 42)

Shoal Creek—One of the Many Tributaries of the Tennessee River to be Made Navigable for Many Miles

"For example, with electric power provided at low cost, *metallurgical processes can be employed in the reduction of ore deposits of the region otherwise unavailable for use. Further, that the fertilizers needed for the profitable production of cotton and now brought from great distances, can be made at low cost in the close neighborhood of the fields in which it is to be used.*† * * * *

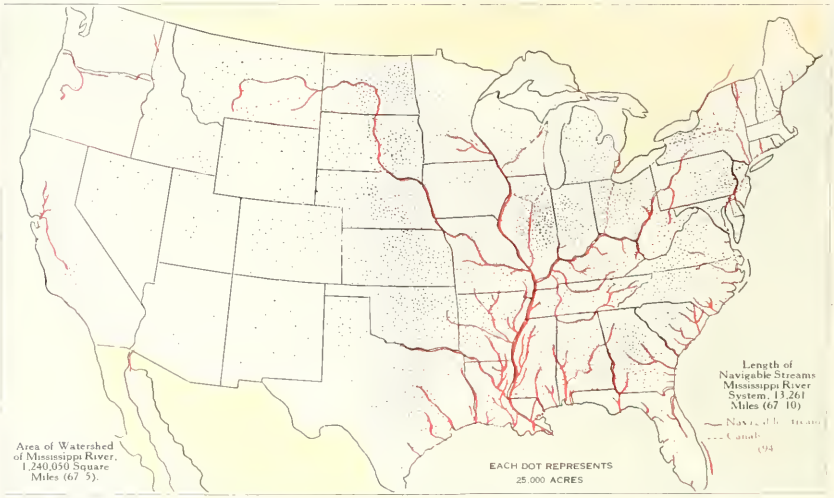
"The board therefore reports that in its opinion it is advisable for the United States to adopt the project," etc., (" 6,7,8).

Here then is the official view of the situation: Muscle Shoals presents an obstacle which can be adequately overcome only at an expense greater than present and anticipated navigation will justify—but when coupled with an industrial development that means cheaper fertilizer and reduced expenses to the American people, the improvement becomes worth while, and the cause of navigation on the Tennessee is given a tremendous impetus by its inseparable association with the great source of cheap waterpower that public safety and national economy demand should be developed at Muscle Shoals.

Were there no navigation interests to be served, and no rich empire, half the size of England, to be brought into greatly increased productivity, still Muscle Shoals would offer a site incomparable for the working out of this great defensive and economic undertaking.

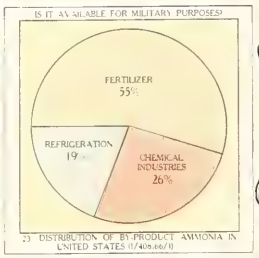
But when to this sound provision for national security and powerful contribution to general prosperity we add the opening to modern navigation of this great river, the placing in unrestricted commission of the magnificent improvements at Hales Bar and the development of a richly endowed but industrially retarded section, then we are able to realize in a measure what nation-wide benefits will follow the establishment of this great nitrate plant at Muscle Shoals.

†The italics are ours



22 Land in Crops Map Showing Also the System of Navigable Waterways Which Provides Cheap Transportation for Muscle Shoals (48 340)

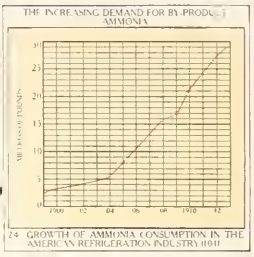
THE NATURAL RESERVOIR ABOVE DAM NUMBER TWO



23 DISTRIBUTION OF BY-PRODUCT AMMONIA IN UNITED STATES (1/406.66/0)

Part Five

A Phantom Opponent



24 GROWTH OF AMMONIA CONSUMPTION IN THE AMERICAN REFRIGERATION INDUSTRY (1/0.0)

Turning the Searchlight Upon the Possibilities of By-Product Coke Oven Production

SHALL WE as a nation place our reliance in by-product coke ovens for our country's supply of nitrogen in peace and in war?

Congress declares *NO!* And there are few who have studied this subject which so vitally concerns the American people who will not agree with this decision.

THE PURPOSES OF CONGRESS

When that body voted twenty million dollars to establish a nitrate plant and placed the selection of a site in the hands of the President, the principal purposes which they desired to accomplish might be stated as follows:

First.—To cheapen our food supply by increasing its production through the agency of a low-priced, effective nitrogenous fertilizer.

Second.—To provide an adequate, controllable and economical, in short a *suitable* source of nitric acid for military use without closing our chemical plants, indispensable in war as well as in peace.

Third.—To make certain that this source of nitrogen supply will be properly located with especial reference to economical production and distribution in times of peace and to adequate protection in time of war.

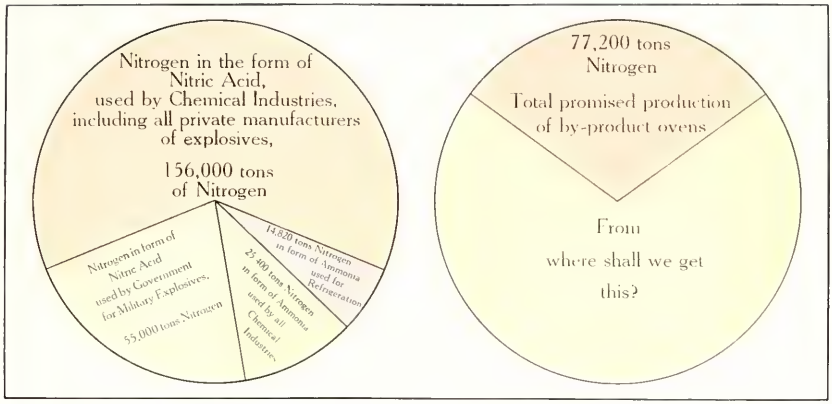
WHY BY-PRODUCT AMMONIA FAILS

Why, then, can we not depend for our supply of nitrogen upon the ammonia produced as a so-called "by-product" in the coking of coal?

First—Because it cannot cheapen our food supply. For, to reduce the cost of foodstuffs we must have much larger crops with the same labor, a requirement which demands large amounts of fertilizer. If we are to use materially larger amounts of fertilizer then we must encourage its extended application by making it much cheaper to the farmer.

No argument is needed to support the statement that the cheaper the fertilizer, the greater the profits in its use, and therefore the greater will be the consumption. A glance at Map 39 (page 43) shows that in the far greater portion of our country no fertilizers

A Typical Battery of By-Product Coke Ovens



25. Forecasted American Consumption of Inorganic Nitrogen in Event of War in 1918 (See Special List for References, P. 63)

are being used at all. From every quarter comes the demand for a reduction in the cost of living, which means more crops on the same land, or in other words, *cheaper fertilizer*.

And what is the reply of the coke oven adherents to the demand for cheaper fertilizer? In the words of one widely experienced, who has contracted for and installed the largest and most important by-product operations in the United States, including those for the United States Steel Corporation:

> "*The by-product coke oven, in order to be worth while, must operate 365 days in the year and sell all of its by-products at a round market price.*"*

This point of view presents the coke oven industry in a new light for it is thus made evident that this "by-product" ammonia is not a by-product at all, but is one of the several principal products which the operators of the misnamed "by-product oven" must produce and sell at a "round market price" to make their enterprise profitable. (Diag. 29, p. 31) As will appear, this is especially true with respect to that product in which we are interested—ammonia, which is approximately 82 per cent nitrogen.

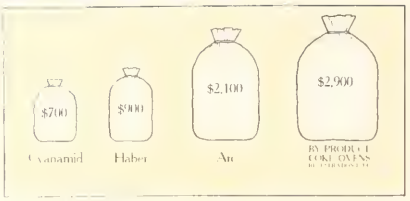
BY-PRODUCT AMMONIA A COSTLY PRODUCT

In further support of the assertion that the so-called by-product ammonia is not a low-priced product we have the statement of a well-known authority on by-product coke ovens who says (p.):

> "The cost of coking by the recovery method is greater than by the old method and the plant cost is a large item, so that *it is essential to the continued progress of this business that the prices received for by-products be maintained at approximately their present level.** Even with products at

*The italics are ours

A Typical Battery of Beehive Coke Ovens



26. Why By-Product Ammonia is Not a Low-Priced Product
Investment Necessary to Produce One Ton of Concentrated Nitric Acid Per Year by Several Processes. Nitric Acid is First Produced as Ammonia (72).

normal prices the large amount of capital involved has prevented the rapid growth of the industry."

It is therefore evident that the business of producing by-product ammonia cannot prosper unless the present prohibitive prices of ammonia fertilizer be maintained.

Then too, the by-product coke oven industry has appeared in Washington with the declaration that:

"Of the by-products recovered, the ammonia is the one yielding the bulk of the return. *It is therefore of paramount importance to the continued growth of this industry that the selling price of this product be maintained somewhere near its normal ten-year average price*"* (58).

What chance is there for the farmer to secure a lower-priced, effective fertilizer from such a source?

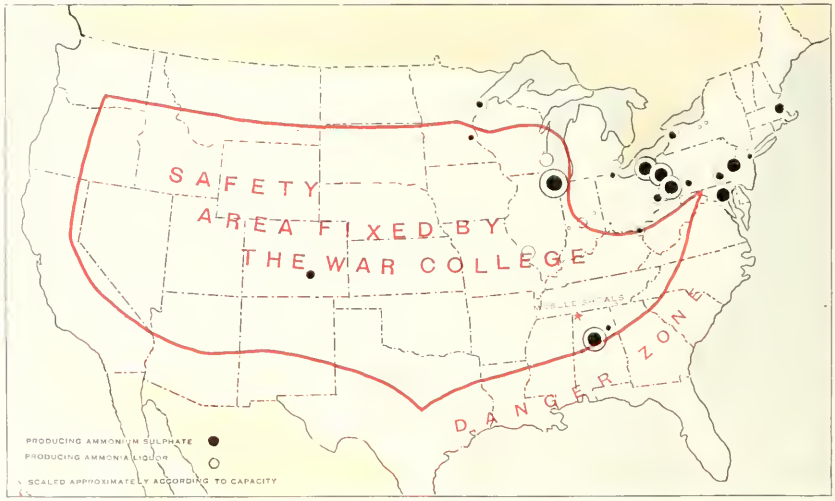
These candid statements are further confirmed by certain studies made for the installation of by-product ovens in Alabama. The advantage to be had from the saving of by-products as compared with their loss in the old-style bee-hive ovens was represented in this case by an estimated income of 84½ cents from the by-products from each net ton of coal. Of this sum of 84½ cents, 55 cents was to be secured from ammonia alone, which was to be sold as sulphate of ammonia at $55.00 per ton at the plant. The average selling price of sulphate of ammonia throughout the country in 1914 was $54.00 per ton (58).

The use of a by-product oven costing $1,100 to $1,200 per ton of coke made daily (Photo, p. 28) to replace the bee-hive oven costing correspondingly $180 (Photo, p. 29), can be justified only when a large return is to be had from the resulting by-products. Certainly it is therefore hopeless to expect a substantial reduction in price on that part of the by-product which furnishes two-thirds of the total return, unless the by-product oven industry is forced to meet the competition of atmospheric nitrogen.

As a source of both ammonia and nitric acid the coke oven process results in a high-priced product. One explanation of this is found in the amount of investment required in connection with the by-product oven as a source of nitric acid. Figure 26, page 30 shows at a glance the comparison between the several processes as regards the investment per annual ton of concentrated nitric acid produced.

It should be noticed that of the four processes for which data are given, three, the Cyanamid, Haber and Arc, are methods employed for the fixation of atmospheric nitrogen. These processes have had their greatest development in Germany, Norway and Italy, the only industry of this character on our side of the

*The italics are ours



27. The Exposed Location of American By-Product Coke Ovens (59)

Atlantic being a Cyanamid plant located on the Canadian side of Niagara Falls.

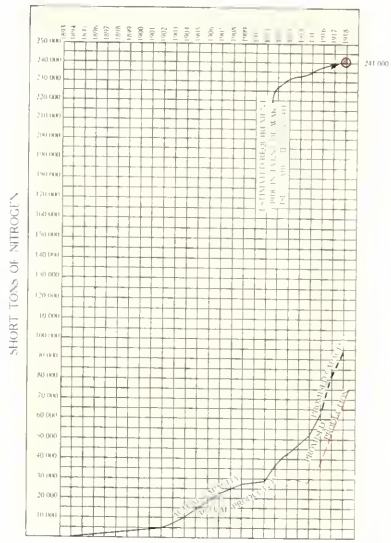
THE IMPORTANCE OF A LOW PRICE

Price is the crucial point of the whole matter. The testimony of the by-product ovens' own champions shows conclusively that they must keep up their prices. Their active opposition to the development of Muscle Shoals seems to confirm it. We want this great national blessing of multiplied crop yields and national protection through the use of cheap nitrogen. We want nitrogen at such a price that we can profitably double its application on present fertilized lands, and profitably introduce its universal use on the unfertilized cereal crops which constitute 60 per cent of the country's cultivated acreage (59), thereby regaining our position as the world's granary and effecting a reduction in the high cost of living to be felt by the very least among our people. The by-product oven offers no means of securing such a price and therefore cannot meet the requirements of the situation.

Second.—In time of war we cannot depend upon the by-product coke oven for our military supply of nitrogen, for, even if we take the expansive promises of the by-product oven people at their full face value, (Diag. 28, p. 31) involving the assumption that the increase in capacity of American by-product coke ovens within the next two years will equal their growth in output during the past twelve years, even then this source of supply would prove to be utterly inadequate to meet the war-time needs of America's private chemical industries alone, to say nothing of the Government demand.

OUR COUNTRY'S NEED FOR NITROGEN

In support of this statement we have undertaken to make a careful analysis (Table II, p. 41) of our country's future need of nitrogen and its probable production. The facts employed are those published by the most reliable authorities on the subject. (Ref's. page 63) We assume that future requirements will amount only to our present consumption plus the normal annual growth prior to the war. This leads us to estimate America's nitrogen needs at too small rather than too large a figure since the rate of increase grows with every passing year.



28 Promises and Performance in the By-Product Coke Industry (59)

THE ENORMOUS SHORTAGE

The results of this analysis have been tabulated (p. 41) and show that *should our imports and exports be cut off by the enemy there would be an annual shortage of 241,520 tons of nitrogen* even after there had been used the promised 77,200 tons from the by-product ovens and after all other available sources of nitrogen had been exhausted. (Diag. 25, p. 29)

The analysis shows further that simply the requirements of the refrigeration and chemical industries including the manufacture of explosives by Government and private plants would amount to 251,220 tons of nitrogen. The chemical industry can use nitrogen only in the inorganic forms such as nitrate of soda, by-product oven ammonia and calcium cyanamid. (Table I, p 32) It is important to notice that the great production of cottonseed meal, blood, tankage, etc., being inorganic

PITCH 50,000 Lbs.	CREOSOTE OIL 50,000 Lbs.	BENZOL 20,000 Lbs.	AMMONIA 7,000 Lbs.	TOLUOL 5,500 Lbs.	SOLVENT NAPTHA 3,000 Lbs. NAPTHALENE 3,000 Lbs.

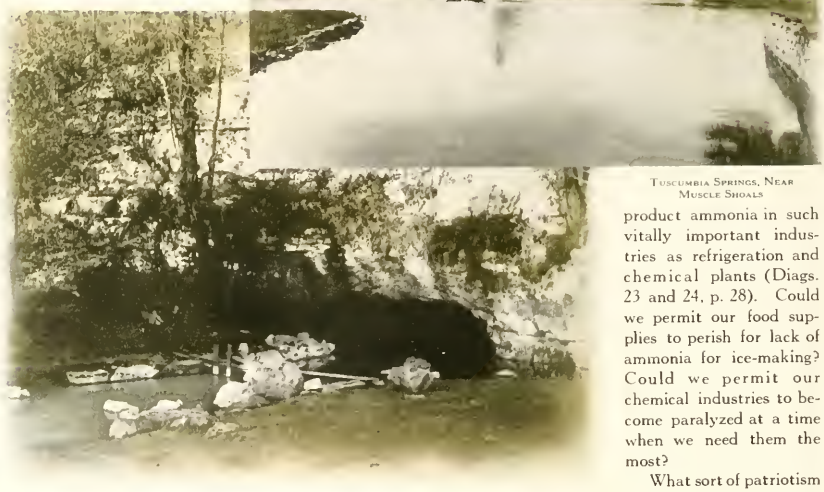
29 The Products Resulting From By-Product Coking of 1,400 Tons of Coal (58, 2)

TABLE 1. *Consumption of Inorganic Nitrogen in U. S. for year ending June 30, 1916.* (111)

Chemical Industries—		
Nitrate of Soda. . . .	156,000 tons	
Coke oven Ammonia.	21,500 tons	
		177,500 tons
Refrigeration Industry—		
Coke oven Ammonia.		12,360 tons
Total Inorganic Nitrogen used		189,860 tons

ammoniates, are of no use in the chemical industries, and hence could not be diverted from use as fertilizer to furnish nitrogen for explosives in time of war.

The experience through which Germany is passing is pertinent to this discussion. Ninety-five per cent of all coke made in Germany is produced with the recovery of the by-products. Diagram 32 (p. 41) shows that Germany's production of coke has *fallen off* 18 per cent since the beginning of the war. In the most perilous period of her national existence, seeking a supply of nitrogen to meet a demand hitherto unheard of in the world's history, Germany has turned *not to* the coke ovens, but *away* from them—and has staked her all upon the atmosphere fixation processes in which she has invested more than one hundred million dollars in the past two years.



TUSCUMBIA SPRINGS, NEAR MUSCLE SHOALS

STIMSON'S HOLLOW SPRING NEAR FLORENCE

These are the facts which should count with us—no theory here—no assumption—but the actual results of the desperate efforts of the most efficient nation in the world.

Our present supplies of nitrate of soda and cyanamid are wholly and entirely imported, and might be shut off completely in time of war. Therefore we face the significant fact that under war-time conditions were we deprived of our imports and exports we could secure nitrogen for explosives and other chemical uses from but the one source—namely, the by-product oven, unless the air nitrogen industry had been previously established in the United States.

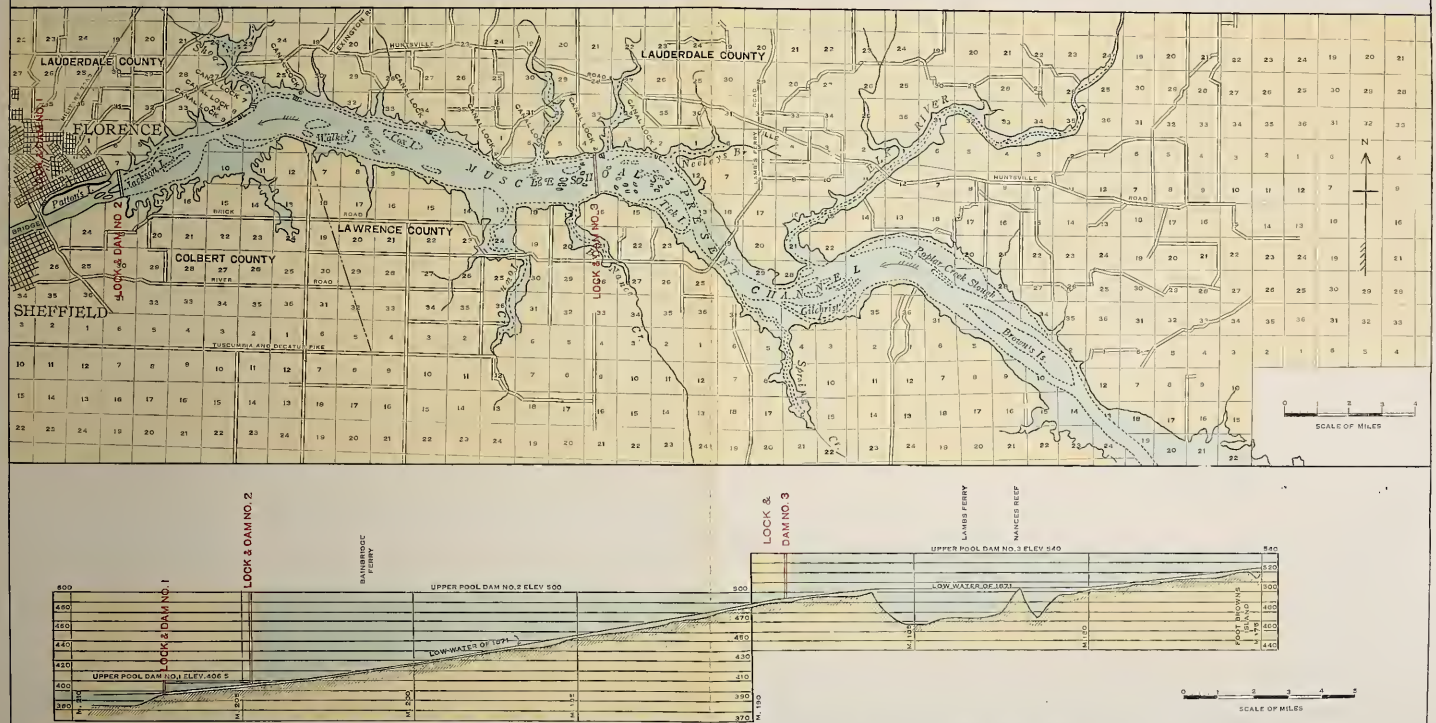
Note the present rapid increase in the use of by-product ammonia in such vitally important industries as refrigeration and chemical plants (Diags. 23 and 24, p. 28). Could we permit our food supplies to perish for lack of ammonia for ice-making? Could we permit our chemical industries to become paralyzed at a time when we need them the most?

What sort of patriotism is it that would commit our country to the suicidal policy of relying upon a single source of nitrogen so grossly inadequate as the by-product coke oven?

Third.—In placing the choice of a site in the hands of the President, Congress intended to make sure that our source of military nitrate supply would be located where it would be safe in time of war.

SAFETY ZONE OF THE WAR COLLEGE

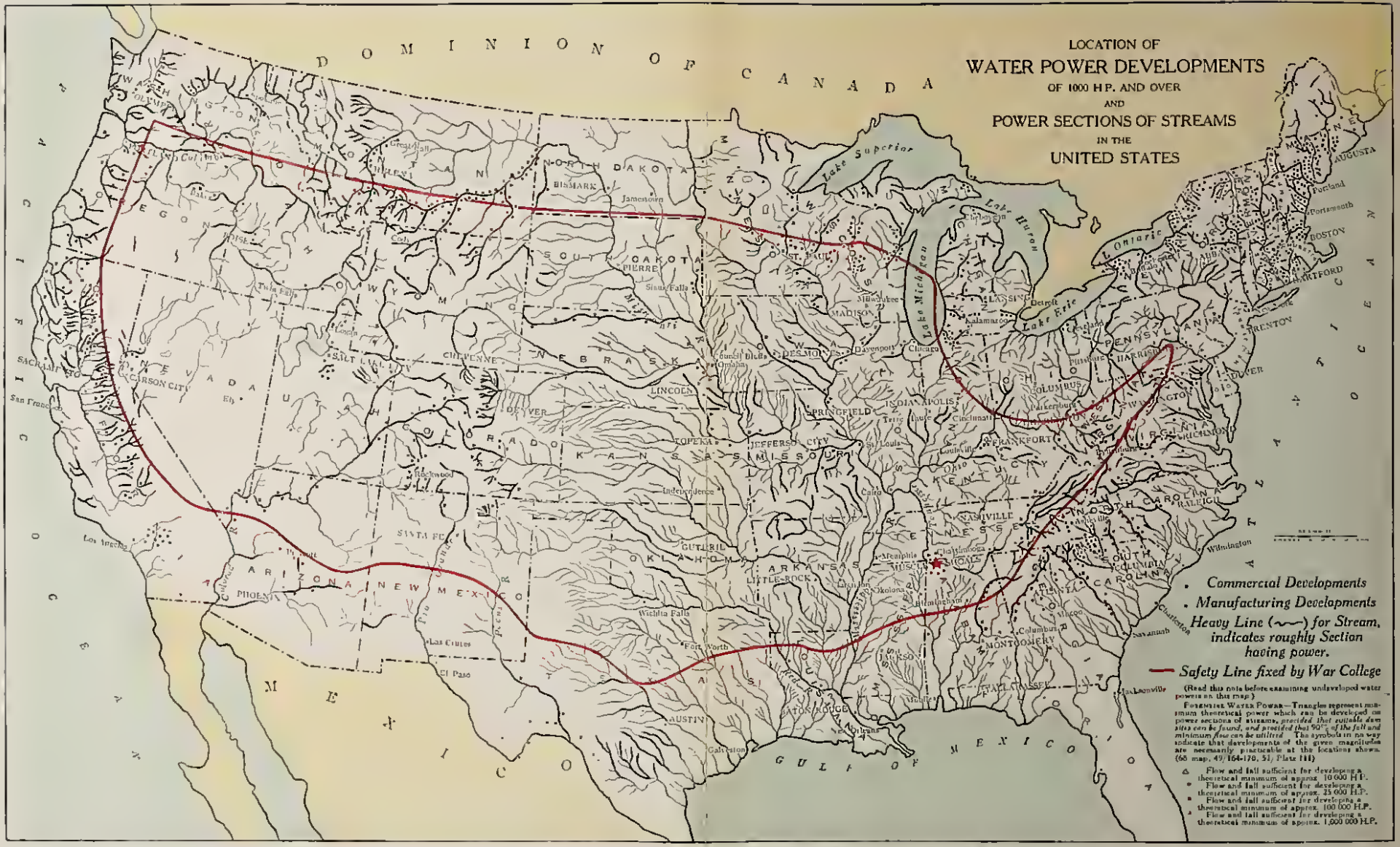
The war college defined the safety area of the United States when they established the line shown in red on the map on page 30. The area in



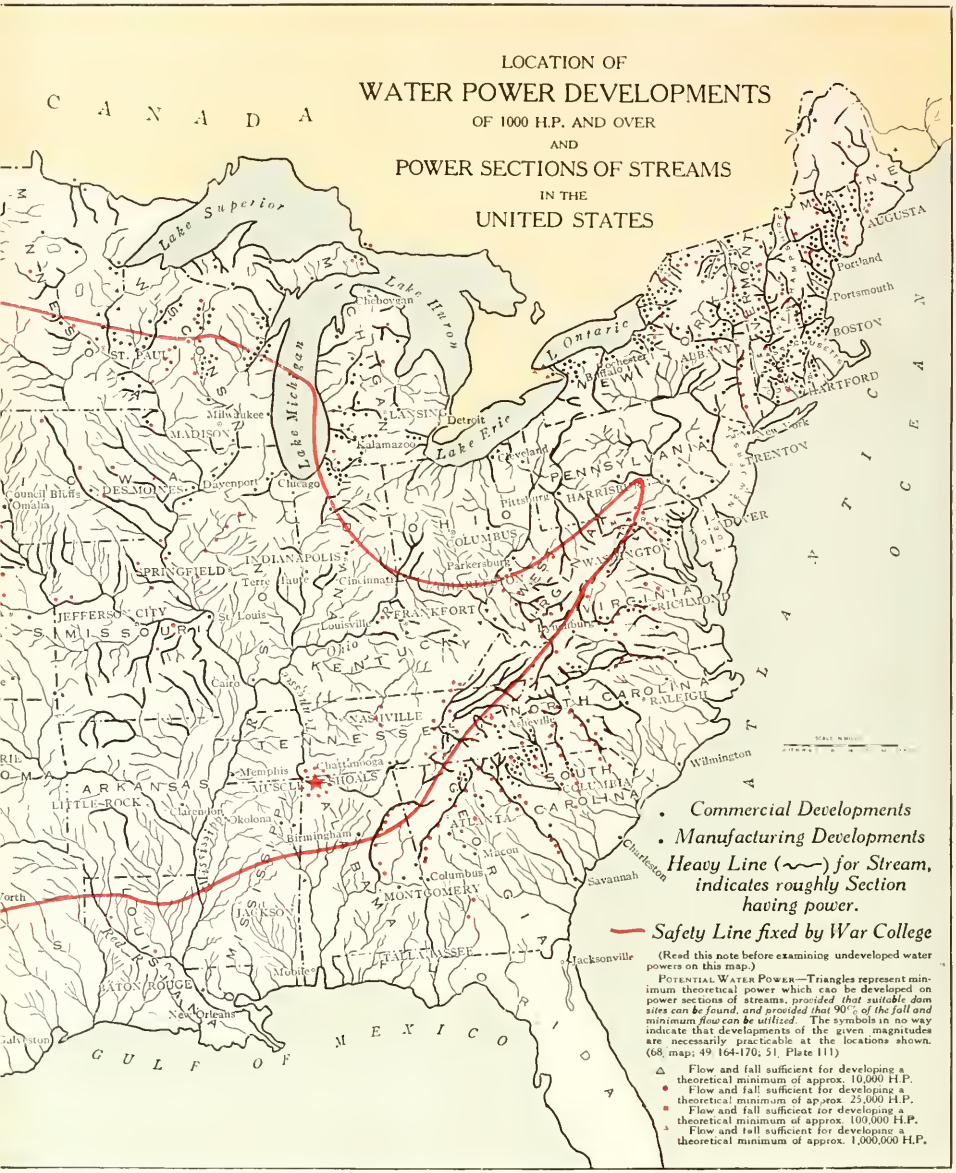
NOTE: Since the above reproduction of the drawings (shown in H. R. Doc. 20, 63rd Cong., 2nd Sess.) was made, a new set of drawings has been published after further investigation by U. S. Government Engineers at a cost of $150,000. (H. R. Doc. 1262, 64th Cong., 1st Sess.). In these drawings the normal elevation of the upper pool formed by Dam No. 1 is fixed at 410.5. The normal level of the pool above Dams Nos. 2 and 3 remains unchanged. Locks and other structures have been designed with a view to providing for 6-foot navigation and a possible subsequent increase in project depth to 9 feet. (51/Plates 33, 35, 46; 51/21)

30. GENERAL PLAN AND PROFILE OF MUSCLE SHOALS IMPROVEMENTS. (51/Plates G-2, G-3, G-4).

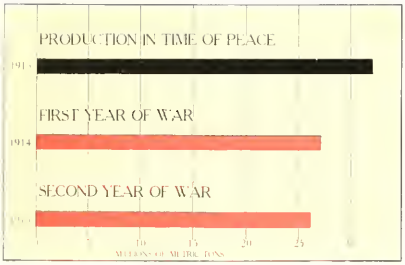
PANORAMA OF TENNESSEE RIVER AT MUSCLE SHOALS



31. POTENTIAL WATER POWER MAP OF THE UNITED STATES (64/Map; 49/164-170; 51/Plate 111)



NITED STATES (64/Map; 49/164-170; 51/Plate III)



32. Production of Coke in Germany (64 6)

white is that zone within which all plants for military purposes supported by public funds must hereafter be built. The black discs show that *fully 85 per cent of the by-product coke oven plants of this country are to be found within the danger area.*

We have seen that our present available natural resources are located outside of this area to a very large extent. (Appendix Map) We have observed with concern that our munitions plants,our steel mills, our blast furnaces and many of our most important deposits of raw materials are in the danger zone, and to a large extent these vital industries not only are located in exposed territory, but are so concentrated within it as to make the isolation of a part of our Atlantic States a matter of most serious concern to the country. Shall we further increase the national danger by producing the first requisite of war, nitric acid, within an area subject to enemy attack?

When we consider safety of construction, the photograph of a typical by-product oven plant (p. 28) shows how vulnerable to attack is the group of brick and sheet iron structures which constitute a by-product oven. How small a bomb could utterly demolish such structures!

Andrew Carnegie says, "Put all your eggs into one basket and watch that basket." One large air-nitrogen plant built of massive reinforced concrete in a protected district is certainly more easily defended than a number of small plants of light construction scattered over the country in exposed locations from Chicago to Birmingham.

Calcium cyanamid can be economically shipped long distances, so that if this process were adopted and the final oxydizing step omitted at the central plant, this operation could be performed in as many small oxydizing plants as considered expedient for military needs, so that the advantages of local production of nitric acid are readily obtainable under the atmospheric fixation plan.

The by-product coke ovens have their place in any scheme of preparedness, and mark an important improvement over the old bee-hive oven, but they do not constitute that big, adequate source of supply which should be at the ready command of Uncle Sam's defensive forces.

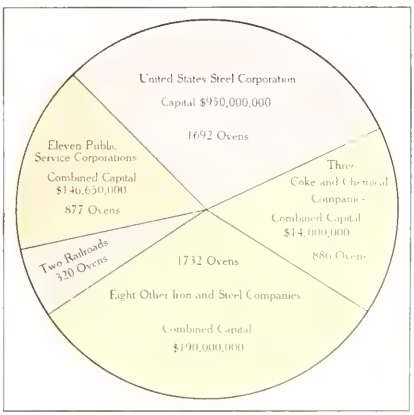
Table 11. *Requirements and Supply of Nitrogen in the United States in 1914 and Estimate of Same in Event of War Early in 1918.* (See special list, page 63, for references.)

Nitrogen Requirements of United States

	Net Tons Nitrogen	
	1914	*1918 (est.)*
Feed Cottonseed Meal	63,500 (*10*)	67,000 (*11*)
Other Organic Ammonia	8,000 (*12*)	14,000 (*13*)
Fertilizers —		
Cottonseed Meal	54,400 (*10*)	56,500 (*11*)
Other Organic Ammonia	61,350 (*14*)	75,750 (*14*)
Inorganic —		37,750 (*16*)
Nitrate of Soda	40,600 (*15*)	
Sulphate of Ammonia	30,900 (*15*)	
Cyanamid Ammonia	4,500 (*3*)	
Refrigeration —		
Ammonia	10,450 (*17*)	14,820 (*18*)
Chemical Industries —		
As Ammonia	14,700 (*19*)	25,400 (*20*)
As Nitric Acid	60,600 (*21*)	156,000 (*22*)
Govt. Military Explosives		55,000 (*23*)
Domestic Consumption	349,000	502,220
Exports, Cottonseed Meal	45,600 (*24*)	
Total Requirements	394,600	502,220

Nitrogen Supply of United States

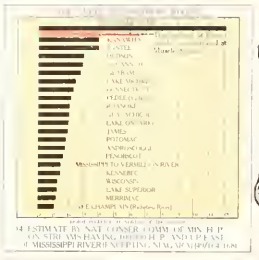
	Net Tons Nitrogen	
Domestic Production:	*1914*	*1918 (est.)*
Cottonseed Meal	163,500 (*1*)	123,500 (*2*)
Other Organic Ammoniates	53,700 (*3*)	60,000 (*4*)
Sulphate of Ammonia	37,700 (*5*)	77,200 (*6*)
Total Domestic Production	254,900	260,700
Imports:		
Nitrate of Soda	101,200 (*7*)	
Sulphate of Ammonia	18,350 (*8*)	
Organic Ammoniates	15,650 (*9*)	
Cyanamid	4,500 (*3*)	
Shortage		241,520
Total Supply	394,600	502,220



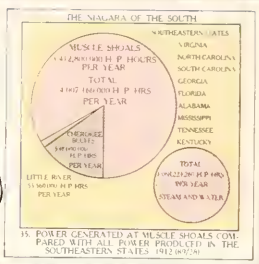
33 Who Owns Our By-Product Coke Ovens? The Respective Shares of the Five Groups Owning the By-product Coke Ovens in the U. S. (I-A 411-414, 57)

Part Six

The Offering of the South



34. ESTIMATE BY NAT. CONSER. COMM. OF MIN. H. P. ON STREAMS HAVING 1000 H. P. AND UP IN MISSISSIPPI RIVER BASIN EXCEPTING NIAGARA AND APPALACHIAN



35. POWER GENERATED AT MUSCLE SHOALS COMPARED WITH ALL POWER PRODUCED IN THE SOUTHEASTERN STATES 1912

What Muscle Shoals Supplies to Meet the Needs of the Nitrate Plant in Time of Peace

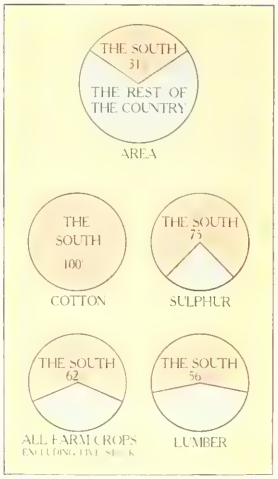
A NEGLECTED SECTION

"Go West, young man," said Horace Greely—and the young man went. Not singly nor by the hundreds did he go, but by the tens of thousands. Occasionally those who took the long westward journey were brilliantly successful, far oftener they were bitterly disappointed, but there in the West they were, and there they generally remained, and thus that section of the country developed.

Stricken by war and poverty, the South had few champions to present its claims in competition with the tempting offers of the golden West, and so the broad wave of development that swept westward during the closing decades of the last century left the great natural wealth of this section neglected and almost unknown.

Thus it happens that the richest undeveloped region in Uncle Sam's domain is located, not in the far West, nor in uttermost Alaska, but within that great populous section which stretches from the Ohio and Mississippi Rivers on the north and west to the coasts of the Atlantic and Gulf.

Herein, as we shall see, is a greater variety of Nature's treasures than is to be found anywhere else in our land. Here the electro-chemical industries can find, in close association, an abundant supply of water power together with all of those contributing factors which make for industrial success and supremacy.



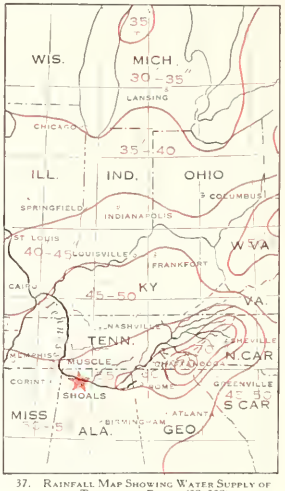
36. SOME PRODUCTS OF THE SOUTH (60 48, 50)

Foremost among the water-powers of this great territory, surrounded by the potential wealth of mine, field and forest is the Niagara of the South Muscle Shoals. Simply to state the conditions and to review the facts is to demonstrate that here is the one site for the Government nitrate plant, capable of meeting the requirements in every particular.

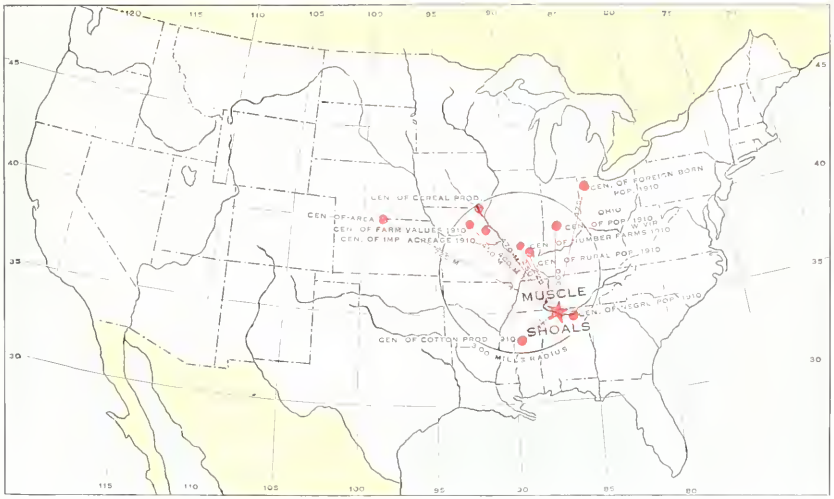
WHAT THE SITE SHOULD SUPPLY

Summing up the requirements of the site that is to produce huge supplies of cheap and high grade fertilizer in times of peace, we have:

1. Power: 200,000 horse-power which must be available for 90 per cent of the time throughout each



37. RAINFALL MAP SHOWING WATER SUPPLY OF THE TENNESSEE RIVER (39 389)



38 Heart of Rural America (37 118, 133, 134, 388, 415)

year, to cost not more than $5 to $10 per horsepower year, if we are to produce at home in successful competition with Norway, where water power is available at $3 to $5 per horsepower year.

2. Raw Materials: Practically unlimited supplies of the following necessary materials close at hand, viz.: (1) Pure limestone; (2) Coking coal; (3) Phosphate rock.

3. Central Location: A site that is central with respect to the great fertilizer consuming districts of the country which are its natural markets, and favorably situated with respect to transportation.

39 Expenditures of Farmers for Fertilizer in 1909 (37 358)

4. Contented Labor: An abundance of low-priced, suitable, contented labor.

5. Mild Climate: A climate that will tend to make the cost of living low, and that will prevent delays and damage due to anchor ice in the penstocks of the power plant.

To what extent, then, is the site at Muscle Shoals able to meet the above requirements, located as it is in the very heart of that rich, undeveloped region—the South?

PHOSPHATE MINING IN TENNESSEE

THE POWER SITE PRE-EMINENT

As a location for a great electro-chemical plant manufacturing fertilizer the site at Muscle Shoals presents notable qualifications and advantages.

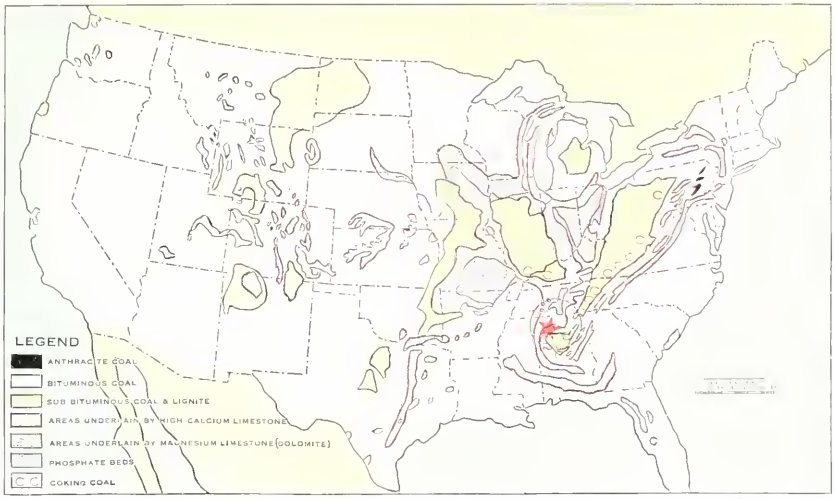
In the vast territory east of the Mississippi, wherein is consumed practically all of the commercial fertilizer used in the United States, (Map 39, p. 43) the greatest potential waterpower center, barring only Niagara Falls, is Muscle Shoals on the Tennessee River. (Diag. 34, p. 42)

Engineering estimates based on extensive surveys and an exhaustive analysis by United States Government engineers of the power demand of the region, give over 600,000 horsepower as the practicable capacity of the generating plant that may be placed at Muscle Shoals, of which 280,000 horsepower would be capable of continuous operation every day of the year. (Diag. 51, p. 55)

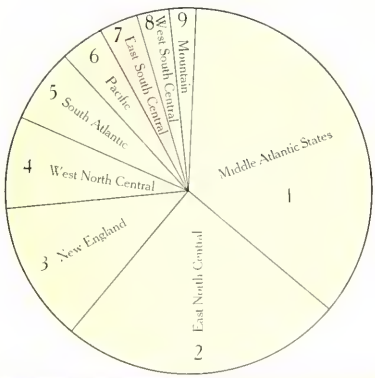
At Muscle Shoals the consumers of electric power need never be limited by the short periods of low water which occasionally occur, for in the case of greatly increased demand beyond all expectations, nearby streams, or the upper tributaries of the Tennessee River could furnish reservoirs from which could be drawn ample power to tide over the driest periods which have occurred in the forty-four years during which the records have been kept. Diagram 51 (p. 55) shows the relation between these reinforcements and the main run-of-river power at the Shoals. Notice that the diagram shows 24-hour power only. If commercial power be considered then 680,000 horsepower can be developed (1,580,000), an amount greater by 105,000 horse power than that of the combined developments on the Canadian and American sides at Niagara Falls (1,938,400).

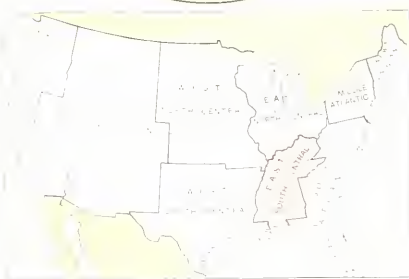
The engineers of the War Department have reported that to produce the energy which is now running to waste over Muscle Shoals would require over a million tons of coal converted into steam or gas power annually, and if the enormous reservoir sites on the Tallapoosa and Little Rivers, or on the upper waters of the Tennessee, be used to reinforce the run-of-river power at the Shoals during the occasional brief periods of low water, which occur during the summer months, then no less than 1,665,000 tons of coal per year would be needed to produce the amount of energy which these running waters offer to him who will make use of them (1,665,400). (Diagram 54, p. 59)

LIMESTONE QUARRIES AT MUSCLE SHOALS



40. Distribution of Raw Materials for Manufacture of Ammonium Phosphate, the New High-grade Fertilizer (Commercial Deposits Only) (37 Plate 452, 26-A Plate 8, 2 49, 54 Plate 3, 55 373, 5 26, 31)





41. The Census Divisions of the U. S. and the Comparative Values of Their Manufactured Products, 1909 (44 81, 37 2)

RAW MATERIALS FOR FERTILIZER

Reference to Map 40 (p. 45) shows clearly that the necessary combination of adequate waterpower and raw materials for fertilizer manufacture, exists in but one location Muscle Shoals. Only in this section of the country can be found a commercial production of the three necessary materials—limestone, coking coal and phosphate rock—all within a radius of one hundred miles.

1. Limestone: The bluffs along the river (Photos, pp. 47-48) are composed of a limestone remarkable for its purity. Samples taken from a nearby quarry showed the following analysis:

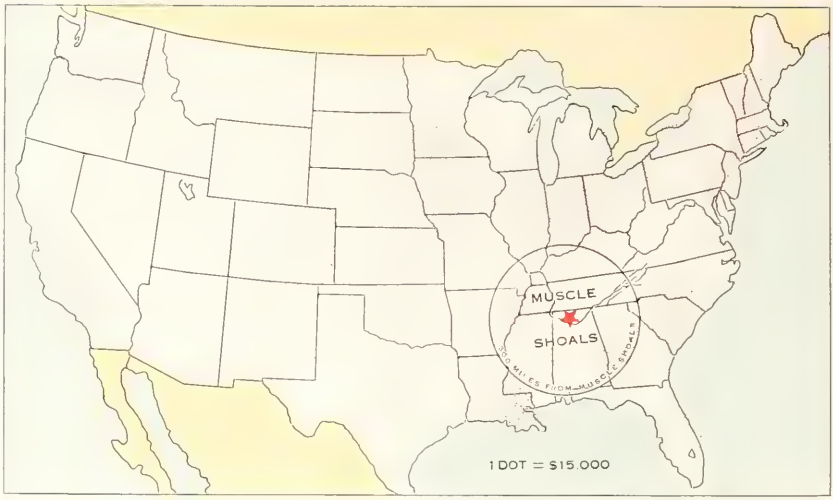
Carbonate of lime	98.17%
Carbonate of magnesia	0.97%
Oxide of iron and alumina	0.30%
Silica	0.49%
Moisture, etc	0.07%
	100.00%

Three other samples from different locations showed an analysis of carbonate of lime differing from that given above by 1 to 2 per cent, or less.

The facility with which this rock may be quarried and conveyed in barges to the fertilizer plant is shown by the photographs on pages 44 and 48.

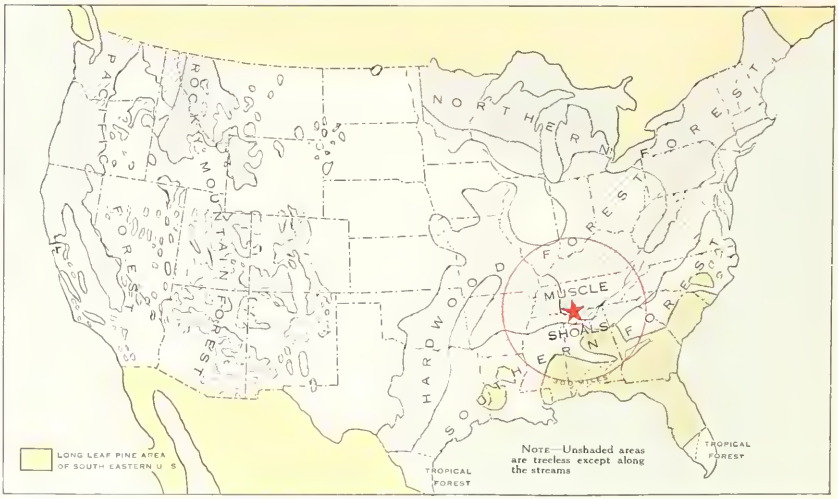
Dr. E. A. Smith, State Geologist of Alabama, describing the limestones of his State [illegible] says:

> "In the northern part of the state this rock is 350 to 1,300 feet in thickness and covers a great area. * * * * * The purer portions of this limestone carry from 95 to 99 per cent carbonate of lime, but with the better quality of the rock, shales are often interstratified. * * * *"



42 Expenditures of Farmers for Labor in 1909 (37 356)

In our consideration of limestones as raw material for the manufacture of fertilizer we must take notice of an important division between them. The two classes are shown in Map 40. (p. 45) The areas shown in black dots are underlain by dolomite, which, while of great value as a flux for the blast furnace, and for other purposes, is not an economical material to use in the manufacture of electro-chemical fertilizer. The areas shown in red dots, on the other hand, are underlain mainly by high-calcium limestone, containing little or no magnesia. This is the kind which is suitable for use in the electro-chemical manufacture of fertilizer (39 167), and it is this kind, of great purity, which is to be had in unlimited quantity and



43 Forest Map (49 Opp. 500, Fig. 2; 49 179, Fig. 1)

Blast Furnace, Tennessee Coal, Iron and R. R. Co., Ensley, Ala.

favorably disposed for economic quarrying, at Muscle Shoals.

2. Coke: Referring again to Map 40 (p. 45), we notice that only small portions of the coal areas of the country are indicated (by the small red C's) as containing suitable material for coking. The transportation of coke or coking coal from the limited areas in which they originate to distant places of use, adds materially to the cost of using coke. For example, in the State of Illinois the average value of the 61,618,744 tons of coal produced in 1914 was $1.14 per ton (U.S.G.S.) but the coke ovens of the State were obliged to use coal brought from Pennsylvania and West Virginia, four parts of which were mixed with one part of Illinois coal to secure a material for satisfactory coking, and the 1,932,132 short tons of coal used in this way were valued at $2.82 per ton (U.S.G.S.), an increase of 147 per cent over the value of the local coals.

But the maker of coke in the Tennessee Valley needs no imported coal. Ninety miles from the site at Muscle Shoals lies the great coke producing district of Birmingham, Ala., second only to the Connellsville district of Pennsylvania. (see Appendix Map)

In the Birmingham district, although the development of the coal resources has hardly begun, sufficient facilities for coke making (some of which are shown in the photographs on pages 28 and 29) are at hand for producing coke in large volume, this district having produced, in round numbers, 3,084,000 tons of coke in 1914 (U.S.G.S.) so that the location of Muscle Shoals with respect to coke supply is all that could be desired.

3. Phosphate Rock: The third fundamental requirement in the manufacture of cheap high-grade fertilizer by modern electro-chemical means is a liberal supply of phosphate rock so located as to permit of economical mining and requiring a minimum outlay for transportation.

Here, again, the location at Muscle Shoals proves itself to be the site par-excellence.

Phosphate rock is produced (in commercially important quantities) in but five districts of the United States. (Appendix Map) Of these, one is in the far west in the heart of the rugged districts of the Rocky Mountains in Wyoming, far removed from centers of fertilizer consumption (District No. 5); a second lies on the Atlantic Coast in South Carolina (District No. 4), but the heavy overburden which must be removed in that district before the rock can be mined increases the cost to such a point that in general it does not pay to ship this phosphate (U.S.G.S.).

Limestone Bluffs Below Florence Bridge

Limestone Quarry, Tennessee Coal, Iron and R. R. Co., Kentona, Ala.

There remain, then, in all the United States only the pebble and hard rock deposits of Florida and the deposits of Tennessee, which in large part are of the highest grade.

The Tennessee deposits have their greatest development within 60 miles from Muscle Shoals, at Mt. Pleasant, Tenn., the second largest producing district in the United States (Photos, pp. 44 and 58). Here is to be found a reserve of phosphate rock containing normally 70 to 72 per cent and as high as 80 per cent pure tricalcium phosphate ($Ca_3(PO_4)_2$) in quantity variously estimated from 88 million ($\frac{1}{11}$) to 160 million ($\frac{1}{20}$) long tons, which is economically mined and washed.

The value to Muscle Shoals of these enormous deposits of phosphate rock right at hand needs only to be pointed out to be fully appreciated, a fact also true of the great supply of timber for construction and other purposes, which is readily available (Map 43, p. 46).

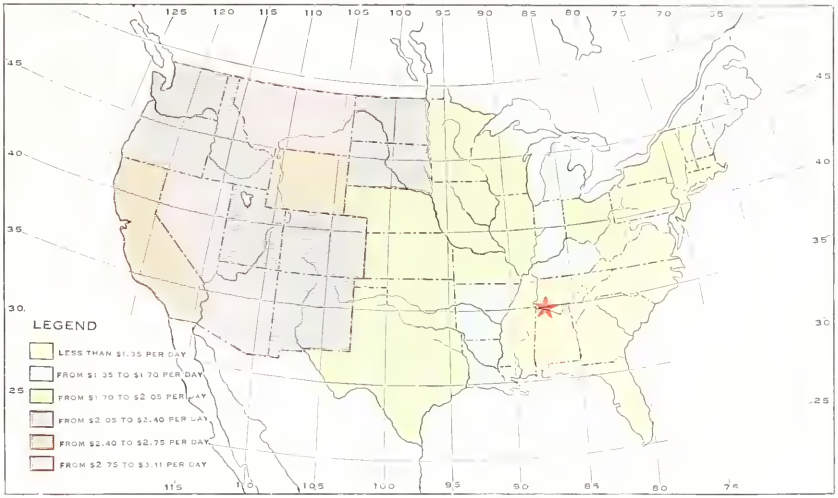
ECONOMY OF CENTRAL LOCATION

In considering so bulky a commodity as fertilizer that site is best adapted for its manufacture, which offers a source of supply nearest to the centers of fertilizer consumption.

The South is, above all things, an agricultural district. With an area of about one-third that of continental United States (exclusive of Alaska) the South produces 62 per cent of all farm crops of the United States, exclusive of livestock, and 100 per cent of all our cotton. (Diag. 36, p. 42) In this warm, moist climate the vegetation grows luxuriantly and constant cropping soon exhausts the soil. The greatest fertilizer consuming district in America therefore, is an area in the South Atlantic States where it has become necessary to use fertilizer in order to produce a paying cotton crop. Map 39 (p. 43) reveals the significant fact that fully 50 per cent of America's fertilizers are consumed within 500 miles of Muscle Shoals, and a radius of 800 miles includes fully 80 per cent of our country's fertilizer consumption. The transportation facilities by rail are indicated, in part, by the network of principal railroads shown in black on the Appendix Map, while the system of some 13,000 miles of navigable waterways connecting with this site are shown in blue. (See also Map 22, p. 26.)

It might be urged that Muscle Shoals lies too far to the southeast to be called a truly central location, but if we consult the Government's Statistical Atlas for 1914 we find (Map 38, p. 43) that Muscle Shoals lies within a circle of 300 miles radius which can truly be said to represent *the heart of rural America*. Inspection of the map shows that within this circle lie the centers of eight of those vital factors of national life by which, rather than by geography, our national center is fixed.

Limestone Bluffs Near Damsite Number Two

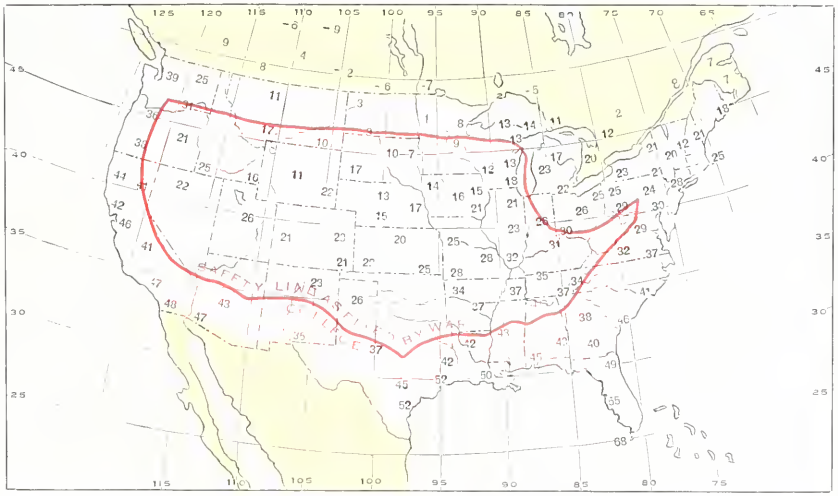


44. Comparative Sums Paid to Wage-earners in American Industries in 1909 (53,228,233)

IMPORTANCE OF SUITABLE LABOR

Abundant cheap and reasonably dependable labor is an important consideration in such specialized work as the electro-chemical manufacture of fertilizer in which the various operations must be carried on continuously, day and night.

The labor cost should be as low as possible, consistent with fair living wages, for, as we have seen, if more general and profitable use is to be made of fertilizer, it must be produced much more cheaply than is possible at present. Moreover, as the plant is to provide for the needs of our army and navy in all emergencies, the labor should be of a loyal and dependable character.



45. Average Mid-winter Temperatures for January, at 8 A. M. (41,147), Showing the Favored Climate of Muscle Shoals that Makes Cheaper Living and Lower-priced Labor Possible

In both of these respects the South has a peculiar advantage. In this section where the climate is mild (Map 45, p. 49) and living is cheaper than in the more rigorous latitudes, the workingman, white or colored, can live contentedly on less than in other sections of the country. (Map 44, p. 49 and Map 42, p. 46)

Freedom from the foreign element in all classes of population, in the central South (Map 52, p. 56) brings to our industries a welcome freedom from a certain undesirable class of foreign workmen, who, having no true conception of the spirit of our democratic institutions, and lacking the inspiration of American patriotism, are a constant source of unrest and discontent.

Map 45 (p. 49) shows the average January temperatures taken at 8 A. M. in various parts of the country. A moment's examination shows that to find a more genial climate we must go to one of three localities: The Pacific Coast, where the haul required is prohibitive; Southwest or Southeast Texas, where there is neither adequate power, phosphate rock, nor coke; or the coasts of the Atlantic and Gulf, where two or more of the necessary raw materials would have to be shipped.

QUALIFICATIONS OF THE PREMIER SITE

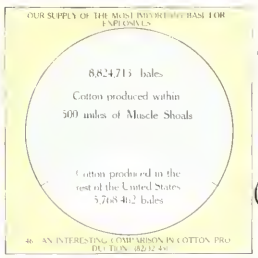
Here is abundance of power capable of development within the necessary limit of cost; and the necessary raw materials, placed as by a Providential hand to meet the great and growing needs of a great nation; here is the central location in the midst of the largest fertilizer consuming district of America and enjoying a water freight rate to the great distributing points of the interior from St. Paul to New Orleans and from Pittsburgh far up the Missouri, while a combination of river and ocean steamers furnishes an all-water route to every seaport on the Atlantic and an adequate system of rail lines brings this site into ready touch with north, east, south and west. Here is satisfactory labor in abundance, and a mild climate. Can another site throughout the length and breadth of the land comply so fully with every requirement? We think not, and we base our championship of Muscle Shoals on its exclusive merits, far-reaching and unquestionable.

Canal Locks at Muscle Shoals

ADVANTAGES OF MILD CLIMATE

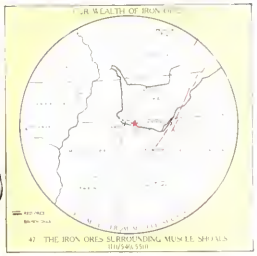
The difference between mild and severe winters can be directly translated in terms of dollars and cents. To the laborer it means less expense for fuel, and fewer requirements for himself and family in clothing. He can live in a house which costs less money and rents for less, and where the changes of temperature are not so severe there is frequently less need for the services of the doctor.

To the hydro-electric operator a mild climate where the streams never freeze means freedom from conditions shown in the photograph of the Keokuk Dam on page 20. No ice jams block the penstocks or runways to the turbines with consequent delay and damage. Transmission lines are seldom severely taxed by heavy coats of sleet and transportation lines are never blocked by snowstorms.



Part Seven

Our National Treasurehouse



What Muscle Shoals and Adjacent Territory Offer to Meet the Needs of the Nitrate Plant in Time of War

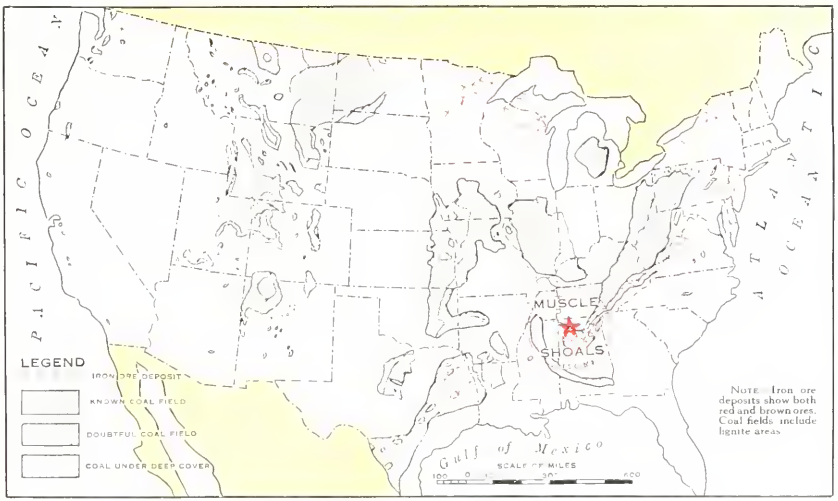
VARIED RESOURCES OF THE TENNESSEE VALLEY

The Tennessee River is in some respects a most unusual stream. It flows both south and north, and it completely divides the State of that name into three distinct parts. It has its source in the majestic Alleghenies, while its lower reaches traverse the level alluvial valley of the Mississippi.

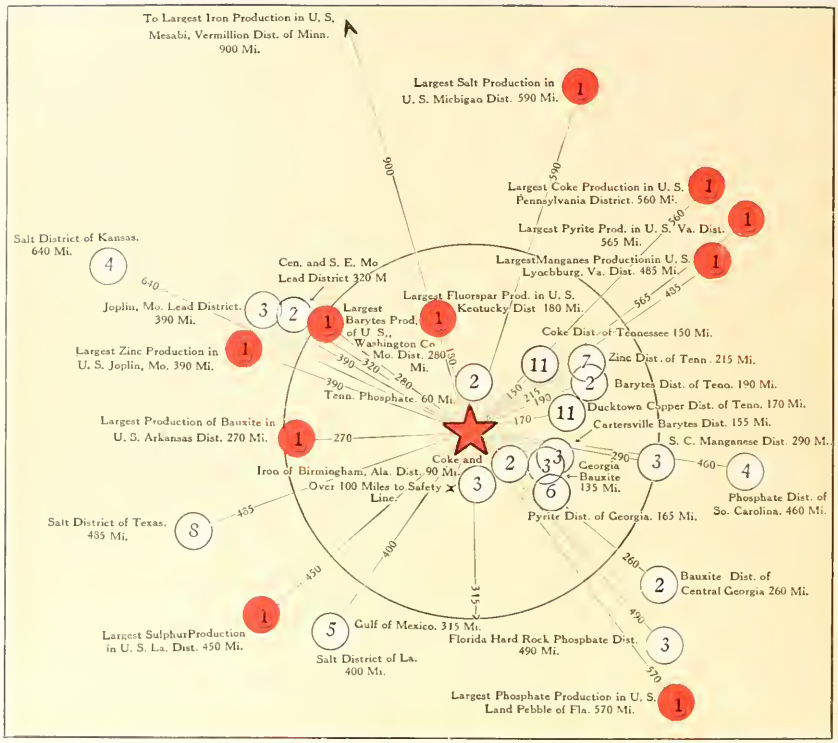
It is but natural that we should find a variety of nature's resources amid the widely varying conditions to be found in the valley of such a stream, yet the statement will be surprising to many that the Tennessee Valley produces substantially every commercially important mineral to be found in America, while every crop mentioned in the census is to be found somewhere in the State of Tennessee. Of noteworthy importance is the fact that these raw resources of mine, field and forest are prepared for use in local industrial plants, and their products are available within a short distance of Muscle Shoals.

How then may a great power site in the heart of the Tennessee Valley meet the needs of our Government in time of war?

Those plants which produce the defensive



48 Distribution of Coal Fields and Iron Ore Deposits in U. S. (9 Plate I. 11 182)



49 Spokes in the Wheel The Producing Districts Surrounding Muscle Shoals (75)

Typical Coal Mine in Eastern Tennessee

equipment of a nation are to a country what its powder magazine is to a great battleship—its vital part. Without them, the nation lies a helpless prey to the modern invader and the heroism of a million men becomes of no avail against the enemy.

QUALIFICATIONS REQUIRED OF SITE

We have seen that the essentials of a suitable site for a great nitrate plant to answer the defensive demands of the country may be summed up as follows:

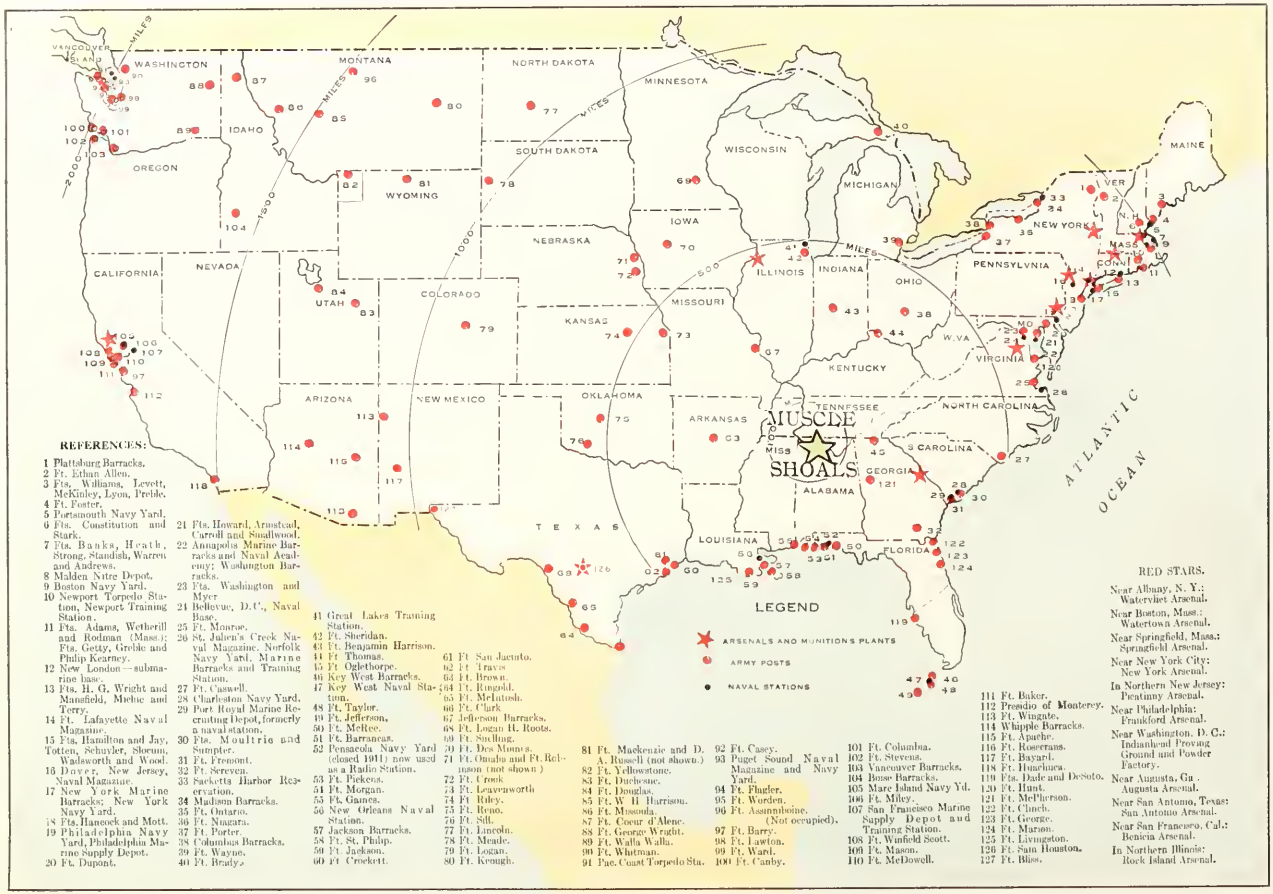
First.—A safe and central location.

Second.—A large supply of continuous cheap, hydro-electric power sufficient for an initial demand of roundly 120,000 horsepower.

Third.—A plentiful supply of raw materials close at hand for the manufacture of nitric acid.

A Fertilized Cotton Crop in Mississippi, 1914

Hale's Bar Improvements on the Tennessee River Near Chattanooga



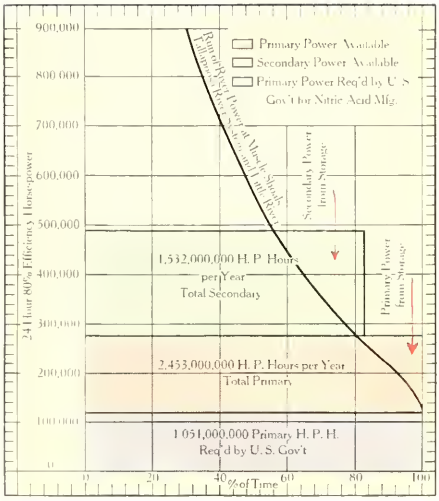
REFERENCES:

1 Plattsburg Barracks.
2 Ft. Ethan Allen.
3 Fts. Williams, Levett, McKinley, Lyon, Preble.
4 Ft. Foster.
5 Portsmouth Navy Yard.
6 Fts. Constitution and Stark.
7 Fts. Banks, Heath, Strong, Standish, Warren and Andrews.
8 Malden Nitre Depot.
9 Boston Navy Yard.
10 Newport Torpedo Station, Newport Training Station.
11 Fts. Adams, Wetherill and Rodman (Mass.); Fts. Getty, Greble and Philip Kearney.
12 New London—submarine base.
13 Fts. H. G. Wright and Mansfield, Michie and Terry.
14 Ft. Lafayette Naval Magazine.
15 Fts. Hamilton and Jay, Totten, Schuyler, Slocum, Wadsworth and Wood.
16 Dover, New Jersey, Naval Magazine.
17 New York Marine Barracks; New York Navy Yard.
18 Fts. Hancock and Mott.
19 Philadelphia Navy Yard, Philadelphia Marine Supply Depot.
20 Ft. Dupont.
21 Fts. Howard, Armistead, Carroll and Smallwood.
22 Annapolis Marine Barracks and Naval Academy; Washington Barracks.
23 Fts. Washington and Myer
24 Bellevue, D.C., Naval Base.
25 Ft. Monroe.
26 St. Julien's Creek Naval Magazine, Norfolk Navy Yard, Marine Barracks and Training Station.
27 Ft. Caswell.
28 Charleston Navy Yard.
29 Port Royal Marine Recruiting Depot, formerly a naval station.
30 Fts. Moultrie and Sumpter.
31 Ft. Fremont.
32 Ft. Screven.
33 Sackett's Harbor Reservation.
34 Madison Barracks.
35 Ft. Ontario.
36 Ft. Niagara.
37 Ft. Porter.
38 Columbus Barracks.
39 Ft. Wayne.
40 Ft. Brady.
41 Great Lakes Training Station.
42 Ft. Sheridan.
43 Ft. Benjamin Harrison.
44 Ft. Thomas.
45 Ft. Oglethorpe.
46 Key West Barracks.
47 Key West Naval Station.
48 Ft. Taylor.
49 Ft. Jefferson.
50 Ft. McRee.
51 Ft. Barrancas.
52 Pensacola Navy Yard (closed 1911) now used as a Radio Station.
53 Ft. Pickens.
54 Ft. Morgan.
55 Ft. Gaines.
56 New Orleans Naval Station.
57 Jackson Barracks.
58 Ft. St. Philip.
59 Ft. Jackson.
60 Ft. Crockett.
61 Ft. San Jacinto.
62 Ft. Travis
63 Ft. Brown.
64 Ft. Ringold.
65 Ft. McIntosh.
66 Ft. Clark
67 Jefferson Barracks.
68 Ft. Logan H. Roots.
69 Ft. Snelling.
70 Ft. Des Moines.
71 Ft. Omaha and Ft. Robinson (not shown)
72 Ft. Crook
73 Ft. Leavenworth
74 Ft. Riley.
75 Ft. Reno.
76 Ft. Sill.
77 Ft. Lincoln.
78 Ft. Meade.
79 Ft. Logan.
80 Ft. Keough.
81 Ft. Mackenzie and D. A. Russell (not shown.)
82 Ft. Yellowstone.
83 Ft. Duchesne.
84 Ft. Douglas.
85 Ft. W. H. Harrison.
86 Ft. Missoula.
87 Ft. Coeur d'Alene.
88 Ft. George Wright.
89 Ft. Walla Walla.
90 Ft. Whitman.
91 Pac. Coast Torpedo Sta.
92 Ft. Casey.
93 Puget Sound Naval Magazine and Navy Yard.
94 Ft. Flagler.
95 Ft. Worden.
96 Ft. Assaniboine. (Not occupied).
97 Ft. Barry.
98 Ft. Lawton.
99 Ft. Ward.
100 Ft. Canby.
101 Ft. Columbia.
102 Ft. Stevens.
103 Vancouver Barracks.
104 Bosse Barracks.
105 Mare Island Navy Yd.
106 Ft. Miley.
107 San Francisco Marine Supply Depot and Training Station.
108 Ft. Winfield Scott.
109 Ft. Mason.
110 Ft. McDowell.
111 Ft. Baker.
112 Presidio of Monterey.
113 Ft. Wingate.
114 Whipple Barracks.
115 Ft. Apache.
116 Ft. Rosecrans.
117 Ft. Bayard.
118 Ft. Huachuca.
119 Fts. Dade and Desoto.
120 Ft. Hunt.
121 Ft. McPherson.
122 Ft. Clinch.
123 Ft. George.
124 Ft. Marion.
125 Ft. Livingston.
126 Ft. Sam Houston.
127 Ft. Bliss.

RED STARS.

Near Albany, N. Y.: Watervliet Arsenal.
Near Boston, Mass.: Watertown Arsenal.
Near Springfield, Mass.: Springfield Arsenal.
Near New York City: New York Arsenal.
In Northern New Jersey: Picatinny Arsenal.
Near Philadelphia: Frankford Arsenal.
Near Washington, D. C.: Indianhead Proving Ground and Powder Factory.
Near Augusta, Ga.: Augusta Arsenal.
Near San Antonio, Texas: San Antonio Arsenal.
Near San Francisco, Cal.: Benicia Arsenal.
In Northern Illinois: Rock Island Arsenal.

50. THE LOCATION OF MUSCLE SHOALS WITH RESPECT TO CENTERS OF DISTRIBUTION OF WAR MUNITIONS (43; 70 164-166, 110)



51 The Electrical Energy That Can Be Concentrated at Muscle Shoals (51 Plate III)

Fourth. Sufficient power and raw materials readily available for the manufacture of war munitions.

Fifth. Favorable conditions with respect to labor and climate, and a local population of purely native Americans.

A SAFE AND CENTRAL LOCATION

In considering the first requirement, a safe and central location, a brief reference to the Appendix Map shows that Muscle Shoals lies well within the safety area fixed by the War College. On an air line it is 570 miles (or farther than from Berlin to Paris) from the nearest foreign territory (Ontario) in which a possible enemy aero-station might be established, 430 miles from the nearest point on the Atlantic coast, and 315 miles from the nearest point (upper Mobile Bay) on the Gulf Coast.

To capture Muscle Shoals from the north the enemy must conquer Ohio, Indiana and Tennessee; from the east he must cross the Appalachian Mountains and the states of Georgia and Alabama, and from the south he must pass the morasses of the Gulf Coast and cross the state of Alabama along its longest dimension.

As to central location, it has been shown (p. 48) that Muscle Shoals lies within that circle of 300 miles radius which, from an agricultural standpoint, constitutes the very heart of the nation. (Diag. 38, p. 43)

But from the military as well as from the agricultural viewpoint, the location of this site is strikingly favorable for economic distribution of nitric acid or other war material. In support of this statement we have prepared a location map of continental United States, showing the government distributing points for war supplies for both army and navy, omitting all camps and headquarters of a probable temporary nature, and including certain forts and army posts not occupied at present, but available in case of war.

Inspection of this map (page 54) shows that by far the greater number are located east of the Mississippi River, so that some 43 per cent of these army posts, arsenals and naval stations lie within a radius of 750 miles from Muscle Shoals.

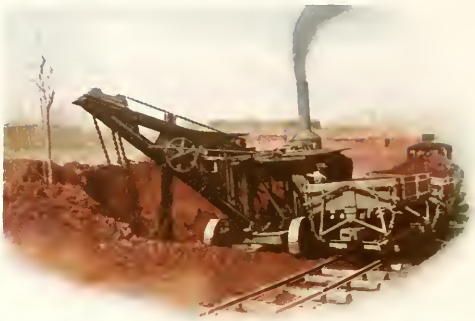
AN ABUNDANCE OF POWER

The second requirement calls for a supply of continuous power, to be available day and night, at all times of the year, to the extent of at least 120,000 horsepower.

Diagram 51, page 55, shows the estimate of the Government engineers, prepared after an investigation covering two years and costing $150,000. This examination was made by Asst. Eng. W. S. Winn, under direction of Maj. H. Burgess, and the report of the investigation was published in December, 1916.

Reference to the diagram shows that the continuous power which may be concentrated at Muscle Shoals is not a bare 120,000 horsepower, the minimum, but a generous 250,000 horsepower and the

Foster & Creighton Limestone Quarries, Rockwood, Ala.



Mining Brown Ore, Birmingham District

ultimate commercial 24-hour power which may be installed there approximates half a million horsepower.

A WEALTH OF NATURAL RESOURCES

The third requirement calls for a plentiful supply of raw materials close at hand, for the manufacture of nitric acid.

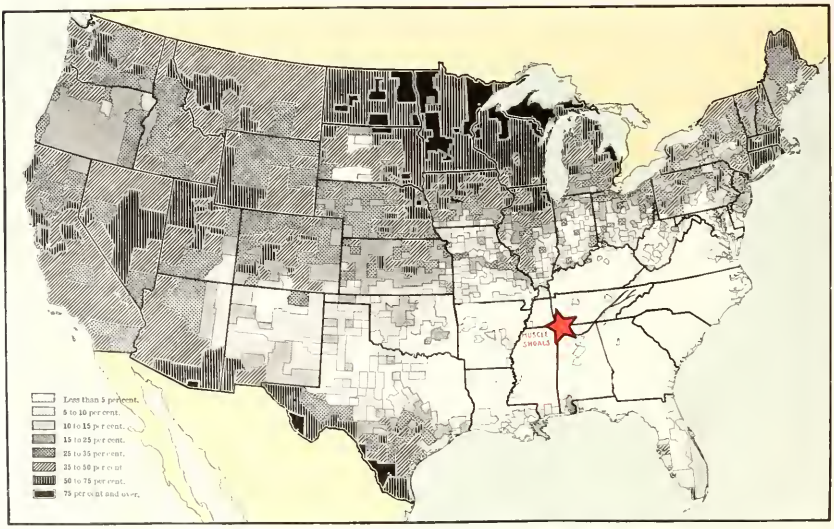
In the electro-chemical method of taking nitrogen from the air, the making of nitric acid is but one step added to the manufacture of fertilizer. This step requires no other raw materials than steam and atmospheric oxygen (O_2), so we see that the site which so abundantly meets the needs of the fertilizer plant is capable of meeting every requirement in raw materials, of the nitric acid plant as well.

When we consider the fourth requirement, namely, the necessary power and raw materials in usable form, for the manufacture of munitions of war, it has already been shown that Muscle Shoals has a tremendous reserve of power available in this location, with possibilities of power development equal to the present development at Niagara Falls.

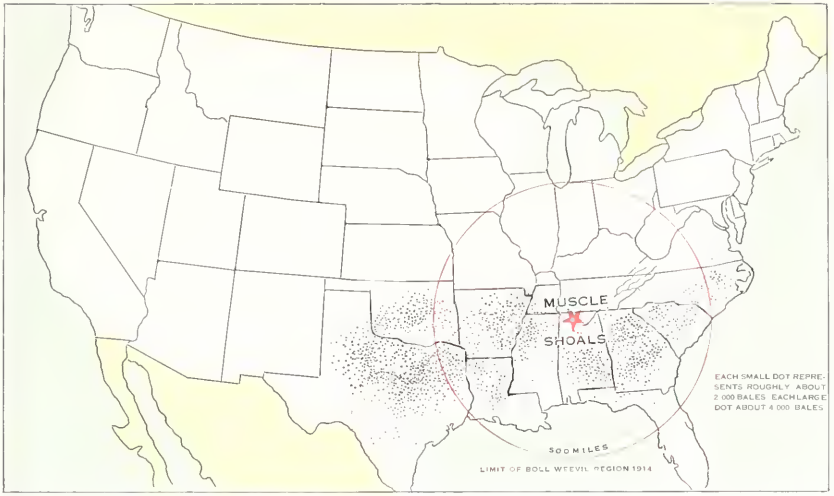
Volumes might be written about the materials available, but space permits us only a brief mention of those requisites that are close at hand to Muscle Shoals.

Cotton, the world's chief basis for the manufacture of modern explosives, is to be had in greatest abundance (see Diag. 46, p. 51; Map 53, p. 57, and Photo, p. 53), for, as we have seen, Muscle Shoals lies but 175 miles from the center of the greatest cotton producing region in the world.

Of the metals for war material there is an abundant and varied supply. Diagram 49, page 52, taken from the Appendix Map shows that the third greatest producing district in America in *iron ores* is but 90



52 Percentage of Foreign Whites, and Native Whites of Foreign or Mixed Parentage in Total Population (37 151)



53 Cotton Production 1914 (48,351) Showing Area Damaged by Boll Weevil (92)

miles away at Birmingham. Here are blast furnaces, smelters and rolling mills (Photos, pp. 47 and 62), but more significant are the tremendous possibilities for *iron and steel* making which would be opened up by the large-scale production of cheap power at Muscle Shoals (Diag. 47, and Map 48, p. 51).

Chief among the improvements in modern steel making stands that industrial giant, the electric furnace. High phosphorous or high sulphur content in iron ores are no obstacles to successful steel making where this powerful servant of civilization is employed, [illegible] so that the Muscle Shoals country with its wealth of iron ore and its great supply of cheap electric power may be made to become the greatest center of iron and steel production in all America.

But iron and steel, important as they are, supply but one spoke in the great wheel of production that has its hub at Muscle Shoals. (Diag. 49, p. 52)

To the northeast, 170 miles distant, lie Ducktown and Copper Hill, the greatest *copper* producing district east of Arizona, excepting only the exposed mining district of northern Michigan. (Appendix Map) (Photos, pp. 18 and 60) Here is to be had *sulphuric acid* in abundance, made from the reclaimed fumes of the smelters. The *zinc* deposits of Tennessee are but 215 miles from the site to the northeastward, while the greatest zinc fields in America, if not in the world, are to be found in the zinc district of southwestern Missouri, 390 miles to the northwest. Here an area of about 100 sq. miles produces 50 per cent of the zinc yield of the entire United States. Smelters in nearby states, at sites having water freight rates, furnish economical sources of supply of this important metal, the nearest being at Mascot, Tenn., on the Tennessee River, 225 miles from Muscle Shoals. (Photos, pp. 61 and 62)

Closely associated with zinc large amounts of *lead* are within easy reach. The production of this metal

Underground Mining, Red Ore, Birmingham District

in the central and southeastern Missouri district, 320 miles to the northwest, (ranking second in lead production) was over 168,000 tons in 1914 (1 ,,).

Aluminum ore, known as *bauxite*, claims an important place in the making of modern munitions. The largest source of this ore in America is the famous Arkansas district, 270 miles westward from Muscle Shoals. This material now goes, in large part, to the great aluminum plant at Niagara Falls. The second largest producing district, 260 miles to the southeast, in Georgia, furnishes abundant supplies of ore to the important aluminum plant at Maryville, Tenn. (Photo, p. 58) but 220 miles from the Shoals.

Important in the manufacture of those grades of steel used extensively for munitions, is *manganese*. The largest producing district of the metal is the Lynchburg district of Virginia, 485 miles from Muscle Shoals, where the ore runs as high as 33 per cent pure manganese. Deposits which rank low in present production and hence are not shown on the Appendix Map, are those of Cartersville, Georgia, 150 miles away, and Independence City, Arkansas, 300 miles distant. The latter is said by Dr. A. H. Purdue, State Geologist of Tennessee, to be the most important reserve of manganese within convenient reach of Muscle Shoals (61 ,).

ARROW PHOSPHATE PLANT, MT. PLEASANT, TENN.

ALUMINUM COMPANY OF AMERICA, MARYVILLE, TENN.

For working steels a good flux is a prime necessity. Muscle Shoals is surrounded by *limestone* (shown in black lines and dots, App. Map) while the largest production of *fluorspar* in America is to be had in the Kentucky district 180 miles to the northward. (Diag. 49, p. 52)

Another important element in the making of explosives is caustic soda, the basis of which is common *salt*. This material is found in beds nearly two thousand feet in thickness, 400 miles to the south in Louisiana, while at a distance of 590 miles is the salt production of Michigan, the largest in the United States.

Sulphuric acid, an important factor in the making of explosives, is available in large quantities at Ducktown, 170 miles away, while *sulphur* and *pyrite*, the raw materials for making sulphuric acid, are available in great quantity. The largest deposit of sulphur in America, if not in the world, is found in Louisiana at a distance of 450 miles from Muscle Shoals. The shipments from this great deposit have reached 1,000 tons per day (1914/915), and it is this deposit which enables the South to dominate the world's sulphur market (60/49).

Pyrite is obtainable in great quantity in Virginia deposits of first rank, 565 miles from Muscle Shoals, while smaller supplies are available in Cherokee and Carroll Counties, Georgia, at a distance of 165 miles.

Barytes for the manufacture of fertilizers, of paints, rubber, paper, and cloth (1914/62) is also available in large amounts in the Washington County district of Missouri at a distance of 280 miles from Muscle Shoals, this district producing about 65 per cent of our domestic output. (Diag. 49, p. 52)

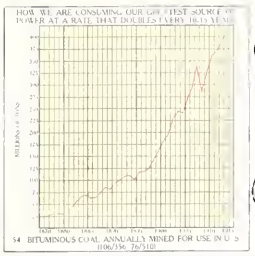
In the construction of a plant of such magnitude as that required by the government *Portland cement* is an important consideration. Dr. Purdue points out that the nearest Portland cement plant is at Richard City, on the Tennessee River, about 150 miles from the Shoals; other plants are found at Kingsport, Tenn., and in Alabama and Georgia. Should a nearer local plant appear desirable, there is an abundance of limestone and shale nearby to supply the material (61/8).

MATERIALS FOR MILITARY HIGHWAYS

An important item in this development is the supply of *road material*. Dr. Purdue states:

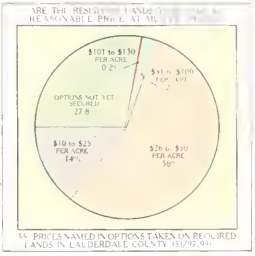
"To the layman it is a natural supposition that first-class military highways would be constructed centering at a munitions plant of the United States wherever it should be located. From Muscle Shoals southward through Alabama well toward the Gulf and northward and eastward through Tennessee and Kentucky there is road material consisting of limestone, chert or gravel on almost every mile of the distance. From the Ohio River northward roads could easily be constructed by the use of limestone that is accessible in many places, and the glacial gravels so widely distributed over the northern states. Westward across portions of western Tennessee and eastern Arkansas there is an absence of first-class road material, but from central Arkansas onward to the great plains it occurs in abundance" (61 ,).

In brief, it may be seen that the combination of such a variety of essential resources is not to be found within so limited an area anywhere else in the land, and when it is considered that in the midst of this abundance and variety is a power site second only to Niagara Falls among the eastern waterpowers, then, and only then, can be comprehended the tremendous possibilities that await the command of our President at Muscle Shoals.



Part Eight

And Finally



If the Nitrate Plant be not Placed at Muscle Shoals, Then Where Shall It Go?

IT surely must go to some locality, for to fail to build this national bulwark, provided by Congress for the protection and welfare of the nation, would be indefensible.

THE PRESSING NEED FOR NITRATE PLANT

We have endeavored to make plain our country's critical need, both economic and military, for a nitrogen plant.

In so doing we have presented information and argument with which the President and Congress are familiar, but which are not generally known or sufficiently understood by the people whose interests are so deeply concerned. One particular phase of the situation, we believe, is worthy of emphasis.

AMERICA A TEMPTING PRIZE

To many Americans who feel that, somehow, the United States of America is a land absolutely invincible; who have concluded that, since America has never seen a Jena nor a Sedan, she never will see one; to those who feel that because we have won the few wars in which we have been engaged, we are a nation of great national defensive strength and are amply supplied with means for meeting the enemy; in short, to all who feel that the need for a great nitrate plant has been exaggerated, we commend a few moments' examination of our country's serious predicament revealed by the map at the back of this booklet.

The heavy line is that to which reference has frequently been made the "safety line" fixed by the War College, limiting the area within which all Government military plants must hereafter be located.

But where are these arsenals and munitions plants today? As shown on the map, every Government munitions plant worthy of the name is to be found within that area along the Atlantic Coast, 225 miles long and less than 100 miles wide, reaching from the Potomac River to Boston Bay.

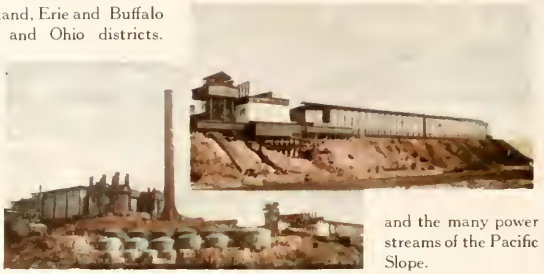
And where are our chief supplies of the all-important iron with which we must wage our warfare? The only iron producing center of any importance in America which is not on the frontier is that at Birmingham, close to Muscle Shoals.

Note that the great iron and steel industry centering around Pittsburgh, depends for its raw material upon ores which are carried along our frontier line for nearly a thousand miles through the Great Lakes,

The Shoals at Lock Number Nine

from Duluth and Marquette to Cleveland, Erie and Buffalo on their way to the Pittsburgh and Ohio districts.

What is the situation respecting copper—another essential material in munitions manufacture? The map shows that it is all to be found within exposed territory, excepting the far western deposits of Nevada and Utah and the Southern source of supply in eastern Tennessee.



Copper Smelters at Ducktown and Copper Hill, Tenn.

It is also a significant fact that the largest producing district in the United States in *lead, salt, coke, pyrite, manganese, phosphate rock* and *sulphur* are in the danger zone, and that, within this area, which would be first to be attacked by a possible foreign enemy, are to be found our principal potential water powers, as well as the majority of our present hydro-electric developments.

With our wealth mounting high into the billions as other nations are plunged into staggering debt, our land offers a tempting prize with its vital military industries concentrated in exposed positions, and with its raw materials within easy grasp of the invader. Who shall say how soon we may have to defend our land from attack?

WHERE SHALL THE PLANT BE BUILT?

Without further argument we ask again where shall this great defensive plant be built if not at Muscle Shoals?

The map shows that the great majority of our power streams possessing the largest possibilities are located outside of the safety zone fixed by the War College. (See also Map 31, pp. 39-40)

This disqualifies practically every power site on the Atlantic Seaboard, the Gulf Coast, the Great Lakes, and the many power streams of the Pacific Slope.

The streams traversing our great central valleys offer but limited waterpower. Keokuk, with its limited supply of water and the prospective high price which power developed there is to command, is not a competitor, and nowhere else except on the Tennessee River is there a site of the requisite magnitude available in the Mississippi Valley.

Nor can we go to the far west with such an enterprise. By nature our most vulnerable coast is the Atlantic and it is here that our vital industries are located. Whether for peace or war, we would defeat our purpose beyond all question by locating our plant in the eastern slope of the Rockies.

The more we study the situation, the more inevitable becomes the conclusion that 250,000 continuous horsepower or half that much coupled with the necessary limestone, coke, phosphate rock, cotton and the extended list of metals, crude chemicals and fluxes so essential in the making of war munitions, are obtainable in favorable combination in but one location in all America—at Muscle Shoals on the Tennessee River.

THE MUSCLE SHOALS OF THE FUTURE

With all of these advantages our story is but half told. For to thus apply nature's forces at Muscle Shoals not only will make living cheaper and provide a secure and dependable source of nitric acid; not only will fully open an inland empire to the needs of the country thru the development of adequate navigation on the Tennessee River; but will establish at Muscle Shoals a center of electro-chemical industry rivaling Niagara Falls in the magnitude and usefulness of its accomplishments.

And so we see this great power site, not merely as a location for the plant that shall produce some necessary acid for use in war, but we see it as the source of an economic influence that shall be felt from coast to coast, lightening in a measure the burdens of the people, bringing the greatest good to the greatest number, and making this enterprise a living monument to that broad principle of democracy.

Iron Mining on the Properties of the Napier Iron Works, Tennessee

Agricultural Limestone Plant, American Zinc Co., Mascot, Tenn.

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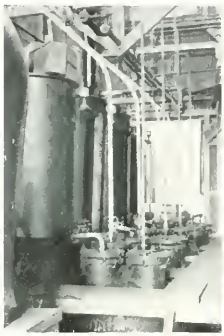
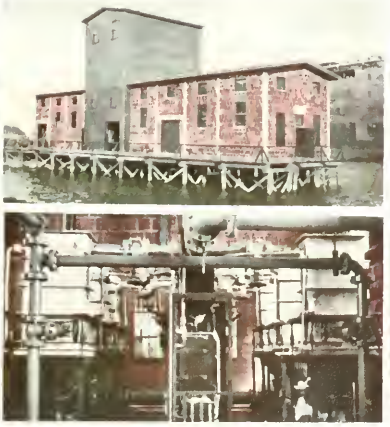
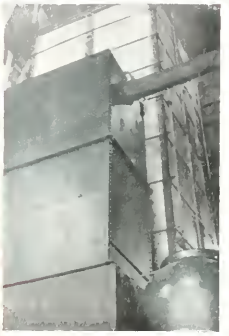


Acid Pumps

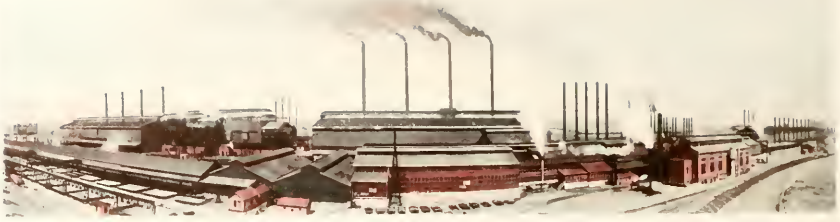


Oxidizing Room



Absorption Room

Ammonia Oxidizing Plant, Ammophos Co., New York City



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1. River steamer (3 to 4 ft. draft) requires following time:
Traversing Canal, 18 miles at 3 mi per hr. 6 hrs
11 Lockages at 30 min 5½ hrs
Total 11½ hrs
2. Tug and 60 barges (4 to 5 ft. draft) require following time:
Each trip 36 miles at 3 mi per hr 12 hrs
Each trip 22 lockages at 30 min 11 hrs
30 round trips at 23 hrs 28 days 18 hrs.
(The canal, of course, was not designed for this type of traffic.)
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Nitrate of Soda—From Oil, Paint and Drug Reporter, Aug. 26, 1916
Coke Oven Ammonia for Refrigeration—From U. S. G. S. Min. Res., 1914, Vol. II, p. 408, to which has been added average annual increase prior to 1914, to bring U. S. G. S. figure to June 30, 1916.
Coke Oven Ammonia for Fertilizer—From Bulletin Bureau of Commerce, Census of Mfgrs. Fertilizer Industry, released July 6, 1916.
Total Ammonia—From Metall. and Chem. Eng., July 1, 1916, p. 39.
Coke Oven Ammonia for Chemical Industries—Obtained by subtracting sum of first three items from total ammonia.

Zinc Concentrating Plants Under Construction, American Zinc Co., Mascot, Tenn.

Special References Regarding Nitrogen Situation in the United States, Supporting Table II, Page 41, and Diagram 25, Page 29

(1) Federal Trade Commission—Report on Fertilizer Industry, 1916, p. 58.

(2) Assumed same as war year 1915, based on relative tons seed crushed 1914 and 1915. Amer. Fertilizer Handbook, 1916, p. 11-6.

(3) Bureau of Commerce, Census of Mfgrs., Fertilizer Industry, released July 6th, 1916, based on assumed value of $2.90 per unit of ammonia. Allow 300,000 tons high-grade organic ammoniate imported, see Ref. 9. Allow 40c per unit P_2O_5 and an average of 5% P_2O_5 in total tonnage.

(4) Based on increase of 90,000 tons organic ammoniates per annum, 1909 to 1914, Ref. 3.

(5) Amer. Fertilizer Handbook, p. 42.

(6) Metallurgical and Chemical Engineering, July 1st, 1916.

(7) Amer. Fertilizer Handbook, 1916, p. 31—Imports for calendar year.

(8) Ref. 7, p. 43.

(9) Ref. 7, p. 25, 32 and Ref. 3 deducting domestic production from consumption (includes cyanamid).

(10) Ref. 1, p. 58.

(11) Consumption equal production, Ref. 2. Divided between feed and fertilizers in same ratio as in 1914—Ref. 1, p. 58.

(12) Ref. 1, p. 73.

(13) Basis increased demands last 3 years as indicated by numerous statements in fertilizer trade journals, and in broker's trade letters.

(14) Consumption, given in Ref. 3, allowing 40c per unit for P_2O_5 and our average of 5% P_2O_5, assuming ammonia worth $2.90 per unit.

(15) Ref. 3 and Ref. 1, p. 29, sulphate of ammonia and nitrate of soda only.

(16) Balance to make total fertilizer consumption equal 88.6% of 1914 consumption on basis of North continuing 1909-1915 rate of increase, and South consuming same quantity as in 1915.

(17) U. S. Geol. Survey—Manufacture of Coke, 1914, p. 408.

(18) Based on annual increase since 1909—Ref. 17, and U. S. Census, 1910.

(19) Difference between production and consumption for fertilizers and refrigeration, Refs. 5, 3 and 17.

(20) Based on consumption of 21,500 tons, 1915 (see Refs. 5, 3 and 17 and Dept. of Commerce, Census of Gas Industry released June 12, 1916), plus annual increase of 1,300 tons per annum (the average rate 1909-1914).

(21) Ref. 7, p. 31. Imports less consumption in agriculture—Ref. 1, p. 29.

(22) Fiscal years ending June 30th (Oil, Paint and Drug Reporter, Aug. 26th, 1916, p. 85).

IMPORTS NITRATE OF SODA

	Short Tons	*Short Tons Nitrogen*
1914	631,735	98,500
1915	646,377	100,300
1916	1,200,335	187,200

Deduct from the 1916 imports of nitrate of soda, 187,200 tons, a quantity equivalent to 77% of the agricultural consumption of nitrate of soda in 1914. (The tonnage of all fertilizers consumed in 1915 was 77% of the quantity used in 1914. See American Fertilizer Handbook, 1916, p. 41.)

(23) Estimate of U. S. War Department of the rate of Germany's requirements per annum during the first nine months of the war, viz., 250,000 tons concentrated nitric acid.

(24) Ref. 1, p. 58.

SITE OF DAM NUMBER ONE (FOR NAVIGATION ONLY) FROM FLORENCE BRIDGE

DESIGNED
ENGRAVED
& PRINTED

by the
BRANDON PRINTING
COMPANY
ART PRINTERS
NASHVILLE


SAFETY LINE FOR MILITARY PLANTS AS FIXED BY THE WAR COLLEGE
RESOURCE MAP OF THE UNITED STATES
FROM 1914 U. S. G. S. AND NAT. CONSERVATION CONG. RECORDS
To accompany Brief for the Location of
GOVERNMENT NITRATE PLANT AT MUSCLE SHOALS
with special reference to Hydro-electric and Electro-chemical Requirements.
Prepared by
NASHVILLE SECTION, ENGINEERING ASSOCIATION OF THE SOUTH
COMMITTEE ON NITRATE PLANT
JOHN HOWE PEYTON, Chairman
WILLIS G. WALDO, Executive Secretary
Published by
THE MUSCLE SHOALS ASSOCIATION
A. M. SHOOK, Chairman
W. R. MAHER, Secretary
NASHVILLE, TENN.
DECEMBER, 1916
LEGEND
Boundary of Safety Zone for Government Military Plants fixed by War College.
Prin. Rivers to be made Navigable by present War Department Projects.
Prin. Non-navigable Streams. (Approx.)
Proposed Sites for Nitrate Plant.
Prin. Railroads. (Approx.)
Area underlain mainly by Mesozoic Limestone
Area underlain mainly by High-Calcium Limestone
Area Producing Cotton
POTENTIAL WATER POWER—Triangles represent minimum theoretical power which can be developed on power sections of streams, provided that suitable dam sites can be found, and provided that 90% of the fall and minimum flow can be utilized. The symbols in no way indicate that developments of the given magnitudes are necessarily practicable at the locations shown. (68/map; 49/164-170; 51/Plate 111)
8,000 to 12,000 H. P.
22,000 to 28,000 H. P.
90,000 to 110,000 H. P.
900,000 to 1,100,000 H. P.
Developed Water Power of 1,000 H. P. or over within 300 miles of Muscle Shoals.
Government Arsenals and Munition Plants
OZARK MTS.
MUSCLE SHOALS
ARKANSAS
SIERRA NEVADA
CASCADE RANGE
OREGON
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
NEW MEXICO
COLORADO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
WEST VIRGINIA
PENNSYLVANIA
NEW YORK
MAINE
VERMONT
NEW HAMPSHIRE
MASSACHUSETTS
CONNECTICUT
RHODE ISLAND
NEW JERSEY
DOMINION OF CANADA
LAKE SUPERIOR
LAKE ONTARIO
LAKE ERIE
LAKE MICHIGAN
LAKE HURON

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NASHVILLE, TENN. — DECEMBER, 1916

NOTES ON THE MINERAL RESOURCES OF THE UNITED STATES

NOTE—The areas of the circles on above map show to approximate scale, the 1914 production of the various districts. The production represented by a one-inch circle is stated for each material at the head of its column, and indicates the scale used. To avoid confusion, the production of minor districts associated with a major district have been included in the output of the latter. In some cases the production of a number of counties has been grouped and platted as a single district.

Material	Annual Production
SALT	8,000,000 Short Tons
COKE	4,500,000 Short Tons
IRON	4,200,000 Short Tons Ore
PHOSPHATE ROCK	1,100,000 Long Tons
COPPER	115,000 Short Tons
BAUXITE	100,000 Short Tons
PYRITE	100,000 Short Tons
LEAD	100,000 Short Tons
ZINC	100,000 Short Tons
FLUORSPAR	110,000 Short Tons
MANGANESE	4,000 Short Tons
BARYTES	45,000 Short Tons

SULPHUR — Arbitrary circles show comparative production, but are not scaled. Quantities not available for individual districts.