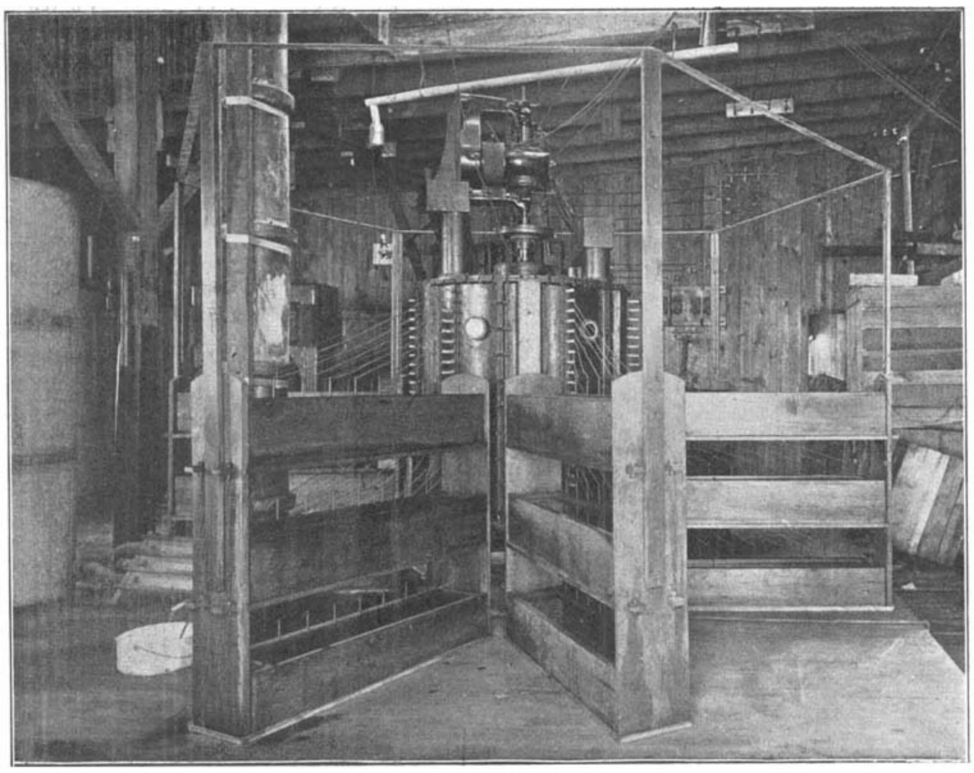
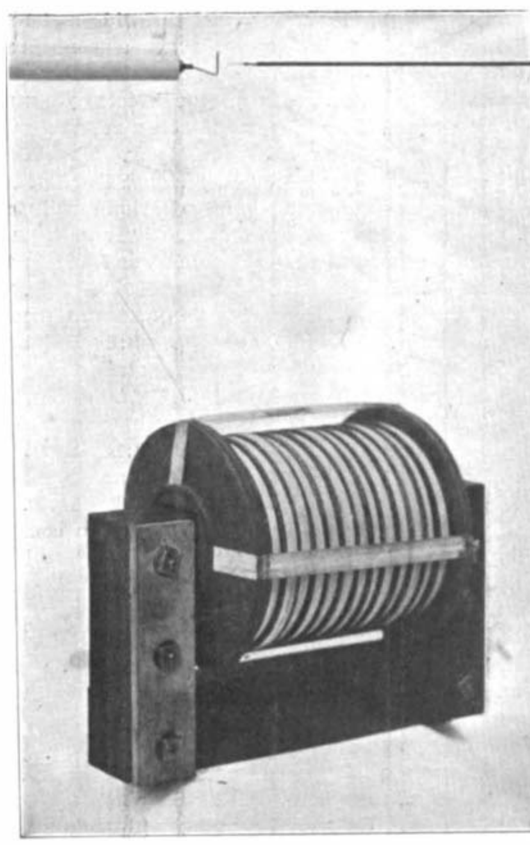
THE COMMERCIAL UTILIZATION OF ATMOSPHERIC ELEMENTS.

In order to properly introduce this subject to our readers we must turn back to the fall of 1898, when the attention of the world was directed to a serious problem. Sir William Crookes in his inaugural address before the British Association discussed the probable future shortage of wheat as a result of the failing supply of nitrogenous fertilizers. He pointed out that guano beds which had for a long time formed the principal supply of nitrogenous manures were almost exhausted, and practically the only compound of nitrogen then available for use as fertilizer was found in the nitrate of soda deposits which cover a limited area in the north of Chile. As a possible solution of this grave question, Sir William Crookes suggested the fixation of atmospheric nitrogen by means of electricity, and predicted that for such an enterprise Niagara would prove the best location, because of the low cost of electricity at that place. A short time after this two American inventors, Mr. Charles S. Bradley and Mr. D. R. Lovejoy quietly began a series of experiments. Seemingly the only thing necessary was to produce a series of powerful disruptive discharges which would burn the air and produce the required gases, but the problem did not prove to be so simple. Difficulties were met from the beginning. A complete history of the efforts and failures of these two inventors would be a long story, but suffice it to say that disruptive discharges were found to give very poor results, and it was only when electric arcs were tried that the subject gave promise of success.



APPARATUS FOR OBTAINING NITROGENOUS COMPOUNDS BY BURNING AIR WITH ELECTRIC ARCS.

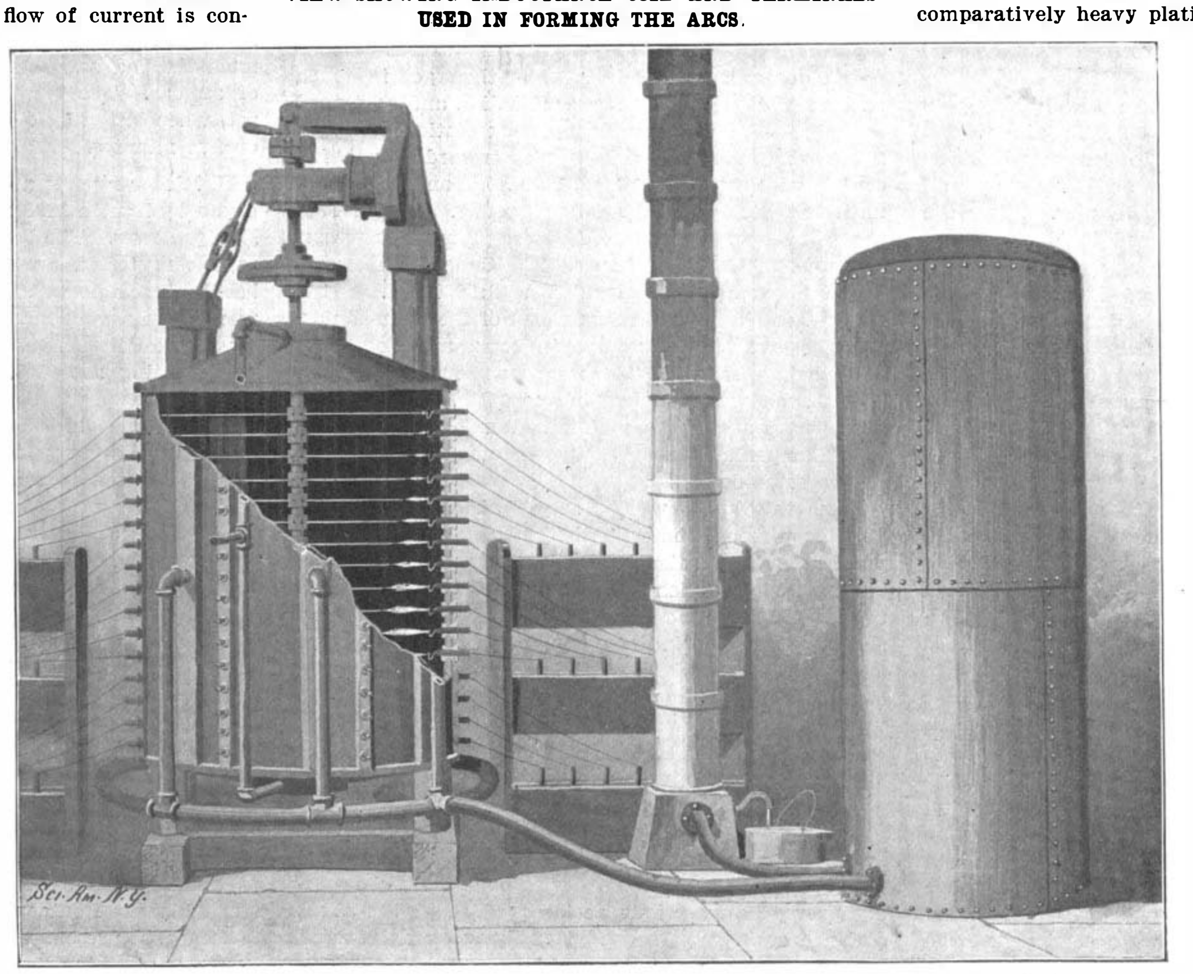
We show herewith several views of the machine which is the culmination of these experiments. Briefly stated, the apparatus comprises an air chamber in which electric arcs are formed between series of stationary terminals and series of revolving wire fingers. The oxygen and nitrogen of the air in the chamber are caused to enter into chemical combination by these arcs, and the resulting gases are drawn off to an absorption tower, where they are combined with various substances to form the required nitrates. Contrary to previous suppositions, the inventors found in the course of their experiments that alternating currents give unsatisfactory results, and so a large direct-current dynamo generating 10,000 volts was procured. This machine was slightly altered to comply with certain special requirements; for instance, it was found that the best work was done by a very slender arc of great length. It was, therefore, necessary to reduce the amperage to a minimum. The positive and negative poles of the dynamo are respectively connected in multiple with the revolving and stationary terminals. The flow of current is controlled by means of an inductance coil in each of the arc circuits, these inductance coils serving to subdivide the current from the dynamo. One of our illustrations shows the form of inductance coils used. The importance of these coils cannot be overestimated, and the greatest care is exercised in their proper adjustment. Each coil comprises 20,000 turns of fine wire and has a self-induction of approximately 150 henries. The coils are submerged in tanks of oil which are arranged in groups radiating from the combustion chamber, the oil being used to insulate the coils. The current in passing through these inductance coils is reduced to any required small value, 0.005 ampere being the amount which is used in this case. The stationary terminals are arranged in the combustion chamber in six vertical rows passing through insulating bushings. Wires from these terminals may be seen leading to the inductance coils. The revolving terminals consist of wire arms extending radially from a center shaft. These wire arms or fingers correspond in number to the stationary terminals and are symmetrically grouped about the shaft in six spirals of one sixth of a turn each. By reason of this arrangement the contacts are made successively in series of six at a time. The revolving shaft is driven by a small motor at the top of the machine, at a speed of 500 revolutions a minute. Thus it will be seen that each finger makes 3,000 arcs a minute. Immediately to the left of each row of stationary terminals is a recess or channel formed in the wall of the chamber. A metal deflector covers the inner face of each channel, leaving a small slit through which the gases resulting from combustion of the air are admitted into the channels and led away into the absorption tower. Fresh air is supplied to the chamber through pipes opening therein at the upper and lower bearings of the central shaft. The purpose of this arrangement is to afford an even distribution of the air and incidentally to cool off the bearings of the shaft. The air before being introduced into the chamber must be thoroughly dry, otherwise the moisture it contains is liable to unite with the gases while still in the combustion chamber to form nitric acid, which would attack the metal parts, break down the insulation, and do considerable damage to the machine. At present the moisture is absorbed by passing the air through calcium chloride, but in the new plant which is now being built desiccation of the air will be accomplished by refrigeration.



VIEW SHOWING INDUCTANCE COIL AND TERMINALS USED IN FORMING THE ARCS.

In the side wall of the combustion chamber are a number of "bull's eyes," or glass-covered openings, through which the observer may watch the arcs. As each wire finger reaches a stationary terminal a small blue spark jumps across the slight intervening air gap, and a flow of electricity ensues, forming an arc which is rapidly drawn out by the rotating terminal to a length of seven or eight inches before breaking. The nature of the arcs is governed by the inductance coils, which at first resist the current and later add their own energy to prolong the arc. When the machine is first started, the arcs give a comparatively white light, but this gradually changes to a reddish hue as the gases are formed. Intense heat is, of course, produced, and it is necessary to tip the terminals with platinum in order to prevent them from wasting away. The purpose of leaving a slight air gap between the negative and positive terminals is to prevent frictional wear, which would require constant readjustment of the parts.

Possibly some of our readers may have noticed that the stationary negative terminal is provided with a comparatively heavy platinum wire, while a very fine wire forms the tip of the positive terminal. This is due to a very curious phenomenon. We all know that the positive carbon in the ordinary arc light is more intensely heated than the negative pencil. It was found that at a certain small value of the current this difference of temperature was reversed, so that the negative became hotter than the positive. This phenomenon was first noticed by Prof. W. H. Freedman, of the University of Vermont. The air as it is burned by the electric arcs forms nitric oxide (NO), which immediately combines with another portion of oxygen and forms nitrous anhydride (N_2O_3). The chemical actions are usually slow, and in order to permit the combination to properly take place the gases are first passed through a large chamber, shown at the right in our illustration, before being drawn up into the absorption tower. The absorption tower is built up of a number of tile-pipe sec-



Combustion chamber. Absorption tower. Intermediate receiving chamber.

GENERAL VIEW OF THE APPARATUS—COMBUSTION CHAMBER PARTLY BROKEN TO SHOW INTERIOR DETAILS.

© 1902 SCIENTIFIC AMERICAN, INC.

tions, and in the formation of nitric acid it is filled with coke. Through this the gases are slowly borne by means of an exhaust fan at the top of the tower, and are brought into contact with water, which trickles down through the coke. Nitric acid (HNO_3) is then formed by the following reactions when the gases are warm: $3\ N_2O_3 + H_2O = 2HNO_3 + 4NO$. The latter product unites immediately with oxygen as follows: $NO + O = NO_2$. This in turn unites with water and forms another portion of nitric acid: $2\ NO_2 + H_2O = HNO_3 + HNO_2$, while the latter product breaks up according to the following equation: $3\ HNO_2 = HNO_3 + 2\ NO + H_2O$. The two molecules of nitric oxide (NO) will then repeat the cycle, beginning at the second equation. If the gases are cold a more simple reaction takes place, and nitrous acid is formed as follows: $N_2O_3 + H_2O = 2\ HNO_2$. This, however, is a very unstable acid and at ordinary temperatures decomposes, as in the fourth equation above, to form nitric acid, nitric oxide and water.

In the production of fertilizer the gases are combined with lime to form calcium nitrate. This is a far better fertilizer than sodium nitrate or Chile saltpeter now on the market, first because there is danger of injury to plant life when the latter is used too freely, owing to the presence of soda, which burns the roots of the plants, and second because lime (which the soil needs) is liberated from the calcium nitrate, instead of soda, which is the result of the decomposition of nitrate of soda (which the soil does not need and which is positively injurious). The cost of producing calcium nitrate according to the process described is less than one-half the present cost of sodium nitrate. In their endeavor to reduce the cost of production to a minimum, Messrs. Bradley and Lovejoy found that the output of the machine is governed by the following three considerations: First, the amount of electric current, which as previously stated, gave the best results at between 0.001 and 0.01 ampere; second, rate of air current passing into the chamber, since too rapid a flow would result in the chemical combination of only a small portion of nitrogen and oxygen of the air, while too slow a flow would permit the gases to pass a second time under the influence of the arcs and dissociate the compounds previously formed; third, the amount of oxygen in the air, the best results being obtained when the gaseous mixture is composed of approximately equal portions of oxygen and nitrogen. Notwithstanding the fact that the machine is already a commercial success, experiments have not ceased. The inventors are thoroughly testing all details, and are busy working along new lines which are constantly presenting themselves.

The first Pacific third rail system was opened in August. The road extends between Riverside and Van Asselt, California, for a distance of about six miles. Throughout the trial run a speed of fifty miles an hour was made.

NEW YORK-BOSTON AUTOMOBILE RELIABILITY TEST —THE FIRST DAY'S TRIP.

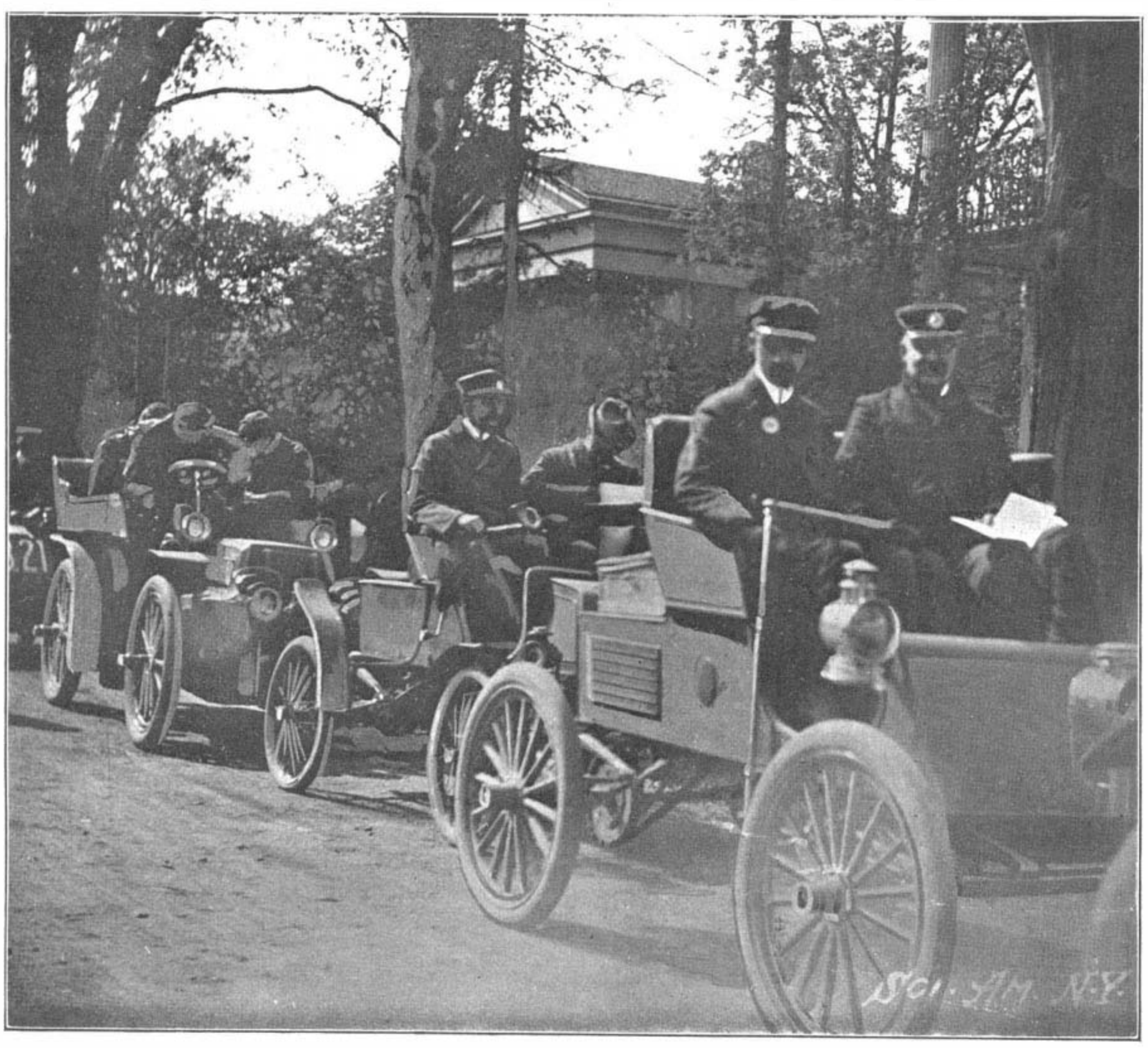
Under a cloudless sky and in the bracing air of a fine October morning, seventy-five of the seventy-eight automobiles entered in the Reliability Test started north on Fifth Avenue from Fifty-ninth Street in this city at 9 o'clock, for New Haven, Conn. The vehicles began the journey at thirty-second intervals by the official timekeepers, stationed at Fifty-eighth Street, and soon formed quite a procession as far as the eye could reach. The operators and observers as a rule had their eyes protected by goggles, while many of the experienced chauffeurs were dressed in the typical dust, dirt and rain-proof black leather suits.

MOUNTING BYRAM HILL, GREENWICH, CONN.--SIXTEEN PER CENT GRADE.

The route followed was north in Fifth, thence west to Seventh Avenue and via Jerome Avenue to Ford ham, then east across to the Sound Shore Road, northeasterly into New Rochelle. From here the old Boston Post Road was followed through the various cities and towns to New Haven, Conn. The first forty-four miles to Norwalk, Conn., where the first control was stationed, were scheduled to be covered in three hours and ten minutes, which constituted an average speed of 14 miles per hour.

The Knox carriage, in which the writer and observer traveled, was one of three of that kind entered in the run. The novel feature of this machine, as illustrated and described in the SCIENTIFIC AMERICAN of March 1, 1902, is an eight horse power air-cooled motor which has numerous heat-radiating pins screwed into the outer wall of the cylinder, upon the head of which a fan, driven by a pulley on the two to one cam-shaft, is constantly blowing. The radiating surface is much greater than that obtained on motors of the flange air-cooled type, while the fan serves to keep the valves and valve springs reasonably cool.

Starting among the foremost of the contestants, two of these machines kept together throughout the whole first day's journey, and all made a perfect record. Not a stop was recorded against them in either of the two stages, and the two that kept together were on time to the minute at the noon and night controls. No bad roads were met with during the entire day's run, though several bad hills were encountered in the vicinity of Greenwich and Norwalk, Conn. Our illustrations give an excellent idea of the train of automobiles mounting the long sixteen per cent grade at Byram Hill, in the town of Greenwich, and the way in which the vehicles were lined up for starting on the second half of the journey at Norwalk. The Knox machines climbed these without perceptible effort, and the low gear was not resorted to in any case till two-thirds of the hill had been traversed. One or two long and rather steep hills, where a good start was obtained, were ascended entirely on the high gear, without once throwing out or "jockeying" the clutch; and on the whole the Knox motor developed fully as much power as any water-cooled motor of its size, and an abundance for propelling its 1,300-pound carriage up the steepest grades. The many advantages and the simplicity of the new system are obvious, and need not be dwelt upon here.



LEAVING NORWALK, CONN.—THE FIRST CONTROL STATION.

By means of a table giving the times at which the different towns should be reached, it was possible to keep close to an average speed of fourteen miles an hour. It was difficult to hold to this speed, which seemed very slow on the smooth stretches of road, especially when many of the more eager contestants would now and then speed past. We were some minutes ahead of our schedule after passing through Stamford, Conn., and so, in company with many others, we were obliged to "lose time" during the last few miles, in order not to exceed our minimum time limit. We passed about a half dozen cars in trouble from punctured tires throughout the entire morning's run; but there were no genuine breakdowns noted, all the machines arriving at Norwalk. A Packard heavy-weight car had a tire give

© 1902 SCIENTIFIC AMERICAN, INC.