fine wax, the paraffine being necessary to make the splint burn easily after the match is struck. The matches next travel over a roller, the lower part of which is immersed in a steam-heated bath of melted phosphorus. As each frame, with its 400 matches, travels across the upper portion of this roller the proper amount of phosphorus is deposited. By the time the matches have traveled in the carrier through the whole circuit of the machine the composition has become thoroughly dried out. The matches are ultimately brought back to the receiving station end of the system, where the circular cam descends between the slats and releases the matches, and they are pushed out of the carrier frame automatically by means of a discharger comb which descends from above the slats for this purpose. The matches are then carried down over an inclined, oscillating table, where they are automatically arranged in parallel piles for convenience of handling. They are then gathered up and taken to the packing tables, where they are put into match boxes of various sizes, and packed in boxes and in crates for shipment.

In closing, it may be mentioned that only 5 boys are required for operating this machine. This may be compared with the older match-making machines for which the services of 25 men were necessary.

Our Coal Exports.

Coal exportations from the United States during the fiscal year just ended, as shown by the Treasury Bureau of Statistics, amounted to $22,317,459, against $19,502,813 in the fiscal year 1900, $13,661,028 in 1899, $11,008,643 in 1897, $10,646,062 in 1896, and $8,391,026 in 1891. Thus the value of coal exportations from the United States has doubled since 1897 and nearly trebled in the decade. These figures relate to values. Measured by quantity the increase has been even greater, the exports in 1901 being 7,676,149 tons, against 2,399,039 tons in 1891, thus making the total exports of 1901 in quantity more than three times as much as in 1891.

The United States now stands third in the list of coal-exporting countries of the world. The coal-export figures of the principal countries of the world in 1899 show that while Belgium slightly exceeded the United States in the total number of tons exported, her imports were more than one-half as great as her exports, making her net exportation of coal much less than that of the United States. The figures of coal exports during 1900 recently published by the British government, a copy of which has just reached the Bureau of Statistics, show that the coal exports of the three principal coal-exporting countries—the United States, Germany, and the United Kingdom—in 1900 were: United States, 7,558,000 tons; Germany, 18,055,000 tons; and United Kingdom, 58,405,000. Thus, while the growth of the coal exports from the United States shows a large percentage of increase, these figures of the exportation of coal from Germany and the United Kingdom show that the field occupied by those countries is still much larger than that which the United States now supplies.

In growth of both exports and production, however, the United States had made much more rapid advance than any other country. The total quantity of coal produced in the United Kingdom was, in 1886, 157,518,000 tons; in 1900, 225,181,000 tons; while in the United States the production was, in 1886, 100,664,000, and in 1900, 245,422,000. Thus the United Kingdom since 1886 has increased her production but about 50 per cent, while the United States has increased hers nearly 150 per cent.

The cost of coal has meantime increased much more rapidly in the United Kingdom than in the United States. The value of the 157,000,000 tons of coal mined in the United Kingdom in 1886 is put by the statement of the British government above referred to at £38,000,000 sterling, and of the 225,000,000 tons mined in 1900, is put at £121,000,000 sterling. Thus, while the quantity mined in the United Kingdom has increased but 50 per cent from 1886 to 1900, the value has meantime increased over 200 per cent. On the other hand, the value of the 100,000,000 tons of coal mined in the United States in 1886 was, according to the same authority, £32,000,000 sterling, and that of the 245,000,000 tons mined in 1900, £67,000,000 sterling. Thus, in the United States, while the quantity increased about 150 per cent, the value of the coal mined increased but a little over 100 per cent.

The relative increase in the cost of coal in the United Kingdom and the United States is shown in an even more striking form in the statement of the British government above referred to by a table which gives the price per ton of coal in the United Kingdom and the United States in 1888 and 1900, respectively. It shows that the price in the United Kingdom advanced from 5 shillings per ton to 10s. 9d., from 1888 to 1900, while in the United States it fell from 6s. to 5s. 5½d. per ton in the same time. Another table in the same statement shows the relative value per ton of coal produced taken at the pit's mouth in the United States, United Kingdom, Germany, France, and Belgium, in 1899, to be as follows:

Country.	Value per ton. Shillings	Pence.
France	9	12
Belgium	9	11
Germany	7	9
United Kingdom	7	7
United States	4	8½

DISTRIBUTION OF COMBINED ELECTRICAL ENERGY.

BY ALTON D. ADAMS.

After electrical energy from scattered water powers and steam plants has been combined and reduced to a common voltage at a main switchboard it is ready to be transformed and converted for any desired purpose. Alternating lines to local transformers, that supply private consumers for 110-volt incandescent lamps, go directly from the main switchboard at about 2,000 volts. These same lines may feed other local transformers that deliver current at 500 volts for induction motors. Such motors are also often supplied by circuits from 500-volt transformers in the sub-station.

Other transformers in the sub-station, of the constant-current type, change constant pressure energy from the board to current at variable pressure for series alternating arcs. To supply direct current energy is drawn from the main switchboard by transformers, which in this case feed alternating motors or rotary converters. If series lines for direct-current arc lamps are to be operated, current from the transformers, at probably 500 volts, will drive alternating motors connected mechanically to the usual types of arc dynamos. A 220-volt, 3-wire, direct-current system is supplied from rotary converters of this pressure, fed by transformers connected with the main switchboard. Street railway and stationary motors requiring 500 volts, direct current, are supplied from still other rotary converters, driven by alternating current from transformers, fed as before. If storage batteries form a part of either the 220 or 500-volt direct system, they draw their charging energy from the same converters that supply the lamps and motors. A variation from the methods of direct-current production just outlined is sometimes made by the use of alternating motors to drive one or more lines of shafting, to which generators for the several sorts of direct current desired are mechanically connected. This plan is easily resorted to where a steam plant in the city served is necessary to supplement the combined water powers during a portion of the time. If the steam station has connected to its main shaft three-phase alternating generators, as well as the dynamos necessary for direct-current service, at times when the water power is sufficient to carry the entire load, these 3-phase generators may draw energy from the main alternating switchboard and, operating as motors, drive their connected shaft and with it the several direct-current dynamos.

Thus far only that sub-station where the energy from various water powers is received and combined has been mentioned, but there may be others. The pressure of about 2,000 volts, adopted for distribution from the main switchboard, is high enough to give a substantial advantage over the 220 and 500 volts necessary on some of the direct-current circuits, in the cost of conductors where a considerable distribution area is to be covered. For this reason minor sub-stations are established at convenient points in the area of distribution, each containing one or more transformers and rotary converters, yielding direct current at 220 or 500 volts, and also in some cases storage batteries, to increase the capacity at periods of maximum load and to steady the pressure. Other minor sub-stations may contain simply transformers, for series lines of alternating arc lamps, or for 500-volt alternating motors, all fed from the 2,000-volt switchboard at the combining sub-station. The methods employed to gather up the energy of scattered waterfalls, transmit it to a common center, combine it for general use, and distribute it over the area of urban service in the forms desired by consumers, have now been outlined. Example of actual accomplishment along these lines may not be uninteresting.

Among the cities of New England numerous instances may be found where the combination of energy from distant water powers for electrical distribution has been carried out to some extent, but two places, Manchester, N. H., and Hartford, Conn., present the most complete examples of the above methods.

At Manchester electrical energy from four separate water powers and two steam plants is received, transformed, combined and then distributed at a single sub-station. One of the water powers is 3 miles, one 6 miles, one 10 miles and one 14 miles from this sub-station. The larger steam plant is less than 200 feet from the sub-station, and the smaller one is three miles away, in the same building with the nearest water power plant. At this nearest water power the electric generators have a combined capacity of 1,090 kilowatts and are operated in varying proportions by steam and water, according to the amount of the latter available. Current is generated at 2,000 volts, alternating by these machines, and then raised by transformers to 6,600 volts for transmission to the sub-station. The water power six miles away drives a single alternator of 1,200 kilowatts capacity, at 10,000 volts, and this energy goes direct to the transmission line without the intervention of transformers. Ten miles from the sub-station the water power drives generators of 600 kilowatts total capacity, at 1,000 volts, and the current is raised to 10,000 volts for transmission. At the greatest of these water powers, 14 miles from the sub-station, the alternating generators now being installed have a combined output of 2,600 kilowatts at 12,000 volts, and are connected directly to the transmission line. The steam plant, close to the sub-station in Manchester, operates alternating generators having a total capacity of 1,250 kilowatts, and dynamos with a direct-current capacity of 1,300 kilowatts, from a single main shaft. These alternating generators, when steam-driven, deliver current at 2,000 volts to the main switchboard in the sub-station, where it is combined with energy from the other steam plant and the four water powers. The direct-current machines have their own distribution boards in the steam-generating station.

At times when the energy from water powers is sufficient the main shaft in the steam station just described is driven by the alternating machines acting as motors and drawing energy from the switchboard in the sub-station. This practice puts the entire load onto the water powers, and converts the steam-generating plant into a sub-station for direct-current distribution. All of the energy delivered at the switchboard in the sub-station is at 2,000 volts, 3-phase, suitable for general distribution to transformers on the premises of consumers for the operation of arc and incandescent lamps and motors. The plans here adopted for the combination of energy from distant water powers make it possible to distribute in the city of Manchester more than 5,400 kilowatts, or 7,200 horse power for direct and alternating electrical service from these sources alone.

At Hartford a separate department of the steam-driven station receives 2,700 kilowatts of electrical energy from two water powers, and there combines it with 2,500 kilowatts from local generators. The two water-power plants are distant, one between 10 and 11, the other between 11 and 12 miles from the Hartford station. At one water power are located generators of 1,200, and at the other of 1,500 kilowatts total capacity, in each case at 500 volts. Transformers are employed at both plants to raise the voltage to 10,000, at which it is delivered to the transmission line and received in the main station at Hartford. Transformers at this receiving station reduce the pressure to 2,400 volts and deliver the energy to the main switchboard. The local steam-driven generators also deliver alternating current at 2,400 volts to this same board in combination with that from the water powers for general use. In this same station other transformers reduce the pressure of a part of the alternating energy from 2,400 volts, for 220-volt rotary converters of 800 kilowatts total capacity, that feed a direct-current, 3-wire system of distribution. At the principal sub-stations, also in the city, but some distance from the steam station, are located other 220-volt rotary converters and their transformers, fed from the main 2,400-volt switchboard. These converters also supply the 3-wire system and charge a large storage battery in the same station, which is used to increase the rate of output and to steady the pressure. At the steam station, and also at two small sub-stations, are located constant-current transformers, which operate alternating arc lamps on series lines for street lighting. These last transformers are also fed by the 2,400-volt system. This system is 2-phase at 60 cycles, and in addition to the transformers for rotary converters and arc lamps supplies those for local incandescent service.

Depth of the Atmosphere Surrounding the Earth.

The Belgian Royal Meteorological Observatory has published the estimates made by various mathematicians and physicists regarding the depth of the atmosphere surrounding the earth. The calculations of the various savants upon this subject are widely divergent. Biot estimated that the depth was only about 40 miles; Bravais, 70 miles; Mann, 81 miles; Callandrau, 100 miles; Schiaparelli, 125 miles; Marie Davy, 187; while Ritter stated that it reached to a height of 216 miles. In Great Britain, during the early part of the last century, the depth of the atmosphere was generally accepted as being 47 miles, but the fact that meteors became incandescent at a much greater altitude incontrovertibly proved that this calculation was fallacious. Sir Robert Ball states that meteors have been observed at a celsitude of more than 200 miles, and since they only become incandescent when they come into contact with the air, the calculation of Ritter appears to be the most correct.

Science Notes.

The British Association meets in Glasgow September 11, and the session will last eight days. It will be followed by a geological tour in the Highlands.

An English clergyman named Bacon is making balloon ascents in and around London with a view to ascertaining the sources of London fog.

Farmers who live on the lines of rural free mail delivery routes are to have the advantage of the Weather Bureau's forecasts of the weather. Arrangements are being made by the Post Office Department and the Weather Bureau to have the mail carts equipped with signals, which will be displayed on the sides. The signals will be conspicuous, so that they can be read at a considerable distance from the highways.

Prof. Woodward, of the Natural History Museum, of South Kensington, London, who has been engaged for some time past in excavating at Pikermi, near Marathon, has recently completed his work. One of his most valuable discoveries is a collection of heads of horned horses. These were unearthed at Euboæ, where the professor carried out some experimental excavations for palæontological remains. In addition to the heads of the horned horses, the heads and shin bones of rhinoceri and other prehistoric animals were discovered. It is curious that out of the six places in the world where the remains of the horned horse have been found three are in Greece and a fourth in Samos, in the Greek Archipelago.

The United States Consular List furnishes some interesting information concerning the tenure of office of our diplomatic corps and consular service. Out of 276 persons employed in these services it appears that 190, or 69 per cent, have served for 5 years or more; that 37 per cent have served for 10 years or more, and that 14 per cent have served for 20 years or more. Three persons have served for 27 years each, two persons 28 years, and one person each 29, 30, 32, 37, and 48 years. The average term of service of persons in the United States Consular and Diplomatic Service abroad has been 9.4 years. From the above figures it would seem that the charge that our consular and diplomatic service is wanting in experience is scarcely sustained, says The National Geographic Magazine.

A novel method of teaching the French language by the phonograph is being attempted in England. Several prominent French professors are devoting their energies to preparing phonograph cylinders carrying French lessons upon them. The phonographic records are accompanied by a book, "The Pictorial French Course." Each book contains thirty lessons, each of which corresponds to a phonographic cylinder, and each lesson is ingeniously illustrated. All that the student has to do is to set the phonograph is motion, and the book will explain what the instrument is saying. The object of this system is to give the French accent correctly.

N. Passerini has carried out a series of experiments on a variety of different plants, from which he draws the conclusion that the parts of a plant exposed to the sun attain a temperature considerably higher than that of the atmosphere; while those not exposed to the direct rays usually exhibit, during the warmer part of the day, a temperature sensibly lower than that of the surrounding air. The greatest difference observed in the case of exposed parts was 17.2 deg. C. The side of fruits exposed to the sun absorbs the greatest amount of heat, and hence assumes a deeper color, and forms the largest amount of sugar. Fruits situated low down, near the ground, absorb most heat, since they receive that reflected from the soil as well as the direct rays. A portion of the heat absorbed directly from the rays of the sun is dispersed by radiation when the calorific rays cease to impinge on the plant; but the increase of potential energy does not proceed exclusively from the purely luminous rays.—Nuov. Giorn. Bot. Ital.

Messrs. Berson and Suehring, the famous meteorological aeronauts of the Berlin Observatory, accomplished a magnificent ballooning feat recently by attaining an altitude of 33,800 feet—almost 6½ miles. This is the greatest height recorded by the instruments carried by the aeronauts, but it is probable that they ascended to a greater altitude. The maximum height they attained, however, is unknown, since both the observers fainted owing to the rarefied atmosphere. The temperature last observed by them was 40 deg. of frost. Herr Berson ascended to 27,000 feet at the Crystal Palace a few years ago. The latest achievement is certainly notable in the annals of aeronautics, but it is not the highest altitude that has been attained by a balloonist. In September, 1862, Messrs. Glaisher and Coxwell ascended from Wolverhampton to a height of 36,000 or 37,000 feet. The exact altitude was not recorded, since the two men were overcome by the intense cold, and the rarefaction of the atmosphere. Mr. Glaisher fainted and Mr. Coxwell only just succeeded in opening the valve by pulling the valve-rope of the balloon with his teeth to enable the vessel to descend.

Engineering Notes.

It is asserted that the number of compound locomotives in use in this country (as compared with simple engines) averages 75 per cent of the whole number in use in freight and passenger traffic.

An English steamship company has issued a circular letter offering free passages to delegates from labor unions who wish to visit this country to ascertain the exact conditions of labor and wages here, and also what advantages, if any, we have in the way of labor-saving tools.

Very curious interpretations of the laws occur at times, so curious that it seems as though the officer in charge did not see his way very clearly to any reasonable settlement. A workman going up the gang-plank of a vessel in an English dock fell and hurt himself so badly that he died in a few days. The judge decided that his family was not entitled to compensation because a ship was not a factory; on appeal this decision was sustained by another court, but further appeal to the House of Lords resulted in a reversal of the verdict that a ship was not a factory. It was a factory to the plaintiff in the action, because that was where he was earning his living; the ship was in drydock and it was a factory, therefore the workman's family were entitled to recover.

A new railway of military strategic importance is contemplated in England, connecting the port of Southampton with the north and center of the country. Southampton is now the sixth port in Great Britain, and is utilized instead of Portsmouth as the embarkation port for the troops. At present, it is only served by one railway, and if connection is desired with the north of the country it is quicker to travel via London. This deficiency of railway communication would be seriously felt in the event of war, since, if the present railway were interrupted, Southampton would be completely isolated. It is therefore proposed to establish direct communication between the port and the military depots and manufacturing centers of England, so that in the event of hostilities men and stores could be quickly transported from the North to the Southern port.

Major Renard, the celebrated military aeronautical expert, has devised a new airship which it is claimed will be superior to that of M. Santos-Dumont. A new type of motor has been constructed by this engineer at the government works at Meudon, but so jealously has its construction been guarded, that no particulars regarding its design are known outside government circles. It is claimed, however, that the motor generates sufficient speed to enable the aerostat to be navigable in all weathers, save a gale. The preliminary experiments with the vessel will be carried out in October and November. They are to be of a very severe and exacting nature, in order to prove the possibilities of the propelling engine. One trial is to consist of a trip from Meudon to Rouen and back, a total distance of 170 miles. Major Renard is confident of accomplishing the journey without a single stoppage and at a fair rate of speed.

Owing to the great success that has attended the inauguration of the turbine passenger steamer "King Edward" on the Clyde, a fresh interest has been stimulated into this new method of marine propulsion. The "King Edward" is to be taken round to the English Channel and will ply for a short while between the various English and French pleasure resorts. If the turbines prove as successful on these routes the trans-channel packets will in all probability be constructed upon the turbine principle. When the Hon. C. A. Parsons, the inventor, delivered a lecture before the Institution of Engineers and Shipbuilders in Scotland upon the marine steam turbine and its application to fast vessels a short while ago he stated that he was particularly interested in its installation upon Atlantic liners, and summarized the advantages that would accrue from its inception, such as increased speed, due to reduced weight, economy of steam, absence of vibration and greater cabin accommodation.

The dangers of the process of storing petroleum in underground tanks were strongly exemplified in London recently. A firm in Hackney Wick had twenty-five of these underground tanks filled with petroleum. The system of discharging water through five separate intercepting chambers was conceded to thoroughly extract all but the smallest portion of the spirit. A heavy storm broke over the district during the afternoon, and the sewers failed to cope with the heavy rush of storm water. Consequently a large amount of water found its way to these tanks and washed away from three of them the puddling clay with which they were sealed. A large quantity of spirit was thus liberated. The storm was followed by a fire in the vicinity of the petroleum tanks, and while the firemen were engaged in its subjugation the petroleum flowing through the streets with the superfluous water exploded with terrific violence. Four people lost their lives and several were injured. Fortunately the concussion did not disturb the other tanks, otherwise an appalling catastrophe would have ensued.

Electrical Notes.

The Marconi station installed on the Nantucket lightship has proved to be very successful and several transatlantic steamers have been able to communicate successfully with the shore by its aid.

The Swedish government is considering plans for the substitution of electricity for steam on all the Swedish railroads, water power being so abundant that large economies would be effected.

The Rochester Railway Company will begin on October 1 to run a trolley car between various parts of the city and the theaters. A charge of 25 cents will be made for the car service, besides the cost of the theater tickets, to which the car coupon will be attached.

The principal electric railway company in Berlin will award two prizes of $750 and $375 each to the best and second best speed indicator for electric cars. The conditions which such a device must fulfill are numerous. The maximum speeds are to be indicated to the motorman by means of visible or audible signals. The device must be also so simple and durable that the jarring of the car will not affect its operation. The competition closed on September 1.

An experiment with electric traction for the towage of barges is to be made on the River Lea, in England. A pair of rails are to be laid down on the towpath of the river, upon which will run a small hauling trolley propelled by the overhead system. It is anticipated that by this means the transit of barges along the river will be considerably accelerated and cheapened. If this experiment proves successful, it is intended to establish a similar system of electric traction in connection with the various canals and waterways of the country. The traffic of goods by barges is very extensive in England, owing to the cost of transport being much lower than that of the railroad.

During the first six months of this year the Central London Electric Railway carried 20,385,739 passengers. of this total 2,190,000 were workmen who traveled the round journey of 13 miles for half fare—2 cents. The earning capacity of the line has been $4,750 per mile per week, and a dividend of 4 per cent was declared. The new electric trams which run from the Shepherd's Bush terminus of the railroad to the more distant suburbs has resulted in the conveyance of 5,000 additional passengers daily. The company now states that they have satisfactorily solved the vibration problem. Experiments have been carried out with a modified engine which so far has overcome the effects of vibration. The company also are experimenting with the idea of dividing the power so that the weight of the engine is distributed over the entire train, and the force of impact due to the weight of the engine on the rails is thus considerably decreased.

It is stated by The Engineer that the General Electric Company of Berlin has just completed near Naples, in the Valley of Pompeii, an installation for the transmission of electric energy, all the conductors used being of aluminium. This installation comprises three horizontal turbines of 150 horse power, working at 190 revolutions per minute. These turbines each drive a tri-phase alternator, and the current, at a tension of 3,600 volts, is led along three aluminium lines to Pompeii, Sarno and Torre Annunziata. The first of these lines, which has a length of about 3 kilometers, leads to a sub-station comprised of two three-phase transformers of 45 kilometers. The second line, which leads to Sarno, has a length of 15 kilometers; it conducts the current to a tri-phase motor working at 3,500 volts, and driving a continuous-current dynamo of 36 kilowatts capacity. This installation supplies a three-wire system at a tension of 240 volts. Finally, the line to Torre Annunziata has a length of 3.5 kilometers, the current serving for motive power in the maccaroni factories in the district.

From a report in The Pall Mall Gazette it will be seen that the syntonic system of wireless telegraphy is not yet being used in His Majesty's navy: When "war" was declared Vice-Admiral Wilson very cleverly turned to account his thorough grasp of the new method of signaling. To the signal staff of his flagship he gave orders that they should not work their own wireless instruments, but should use these to read off the messages transmitted between the enemy's ships when the latter were near enough. . . . By thus using his wireless telegraphy instruments as ears instead of tongues, Vice-Admiral Wilson was enabled to gather a good deal of valuable information about his opponent. Sir Gerard Noel, the Commander-in-Chief of "B" fleet, it appears, adopted the ordinary naval code for his war signals, with the slight alteration that instead of making only three letters he made five, two of which were dropped when deciphering the message. It did not take the quick-witted signalmen of "X" fleet long to get the key to "B" fleet's code sufficiently to read all of its messages that were picked up by their instruments. Vice-Admiral Wilson took good care to issue for his own fleet a code that could not be deciphered by the fo.