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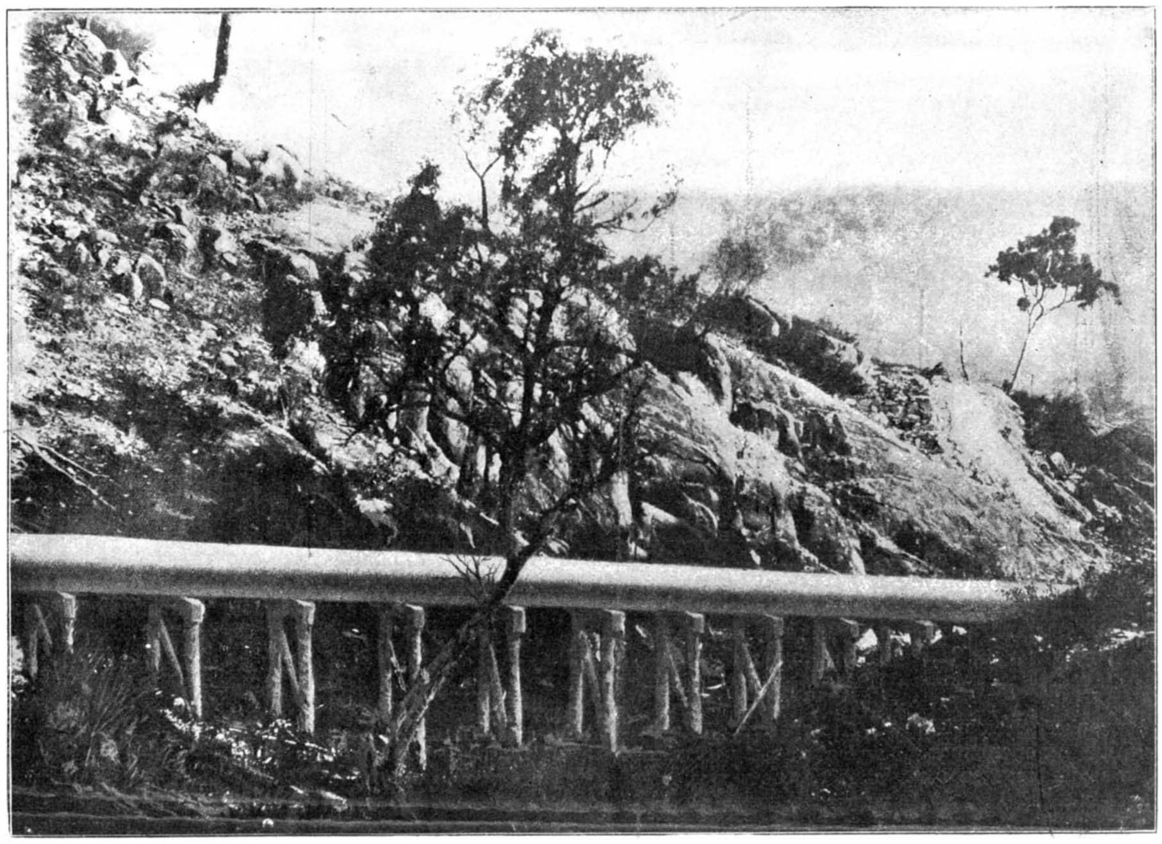
THE COOLGARDIE WATER WORKS.

By the English Correspondent of the SCIENTIFIC AMERICAN.

ONE of the most interesting and remarkable feats of engineering, and which is certainly one of the largest of its kind in the world, is that in connection with the water works scheme for the supply of the Coolgardie gold fields in Western Australia, which is now approaching completion. These gold fields, which were first discovered in 1892, comprise the great groups of mines at Kalgoorlie, Coolgardie, and the surrounding neighborhood. They are situated about 363 miles distant from the port of Fremantle on the west coast of Australia. To reach the gold fields from the seacoast, it is necessary to traverse first 100 miles of granite ranges averaging 1,200 feet high, thickly forested with gum trees, etc., and then the country extends in a series of broken, rolling, sandy, scrub-covered plains gradually rising toward Coolgardie. This desert is practically waterless, as the average rainfall is only 7.14 inches, while the evaporation is 82.6 inches, with a temperature which often exceeds in summer 100 deg. Fahr.



PIPE CROSSING GULLY.

Indescribable suffering and heavy loss of life attended the great rush to the fields in 1893. At that time the railroad only extended as far as Southern Cross, some 235 miles from the coast. The remaining 128 miles had to be covered in any available vehicle or on foot. The heavy mortality attending the rush to the gold fields was mostly due to typhoid, attributable to the scarcity of drinkable water during this second section of the journey, which cost 40 cents per gallon.

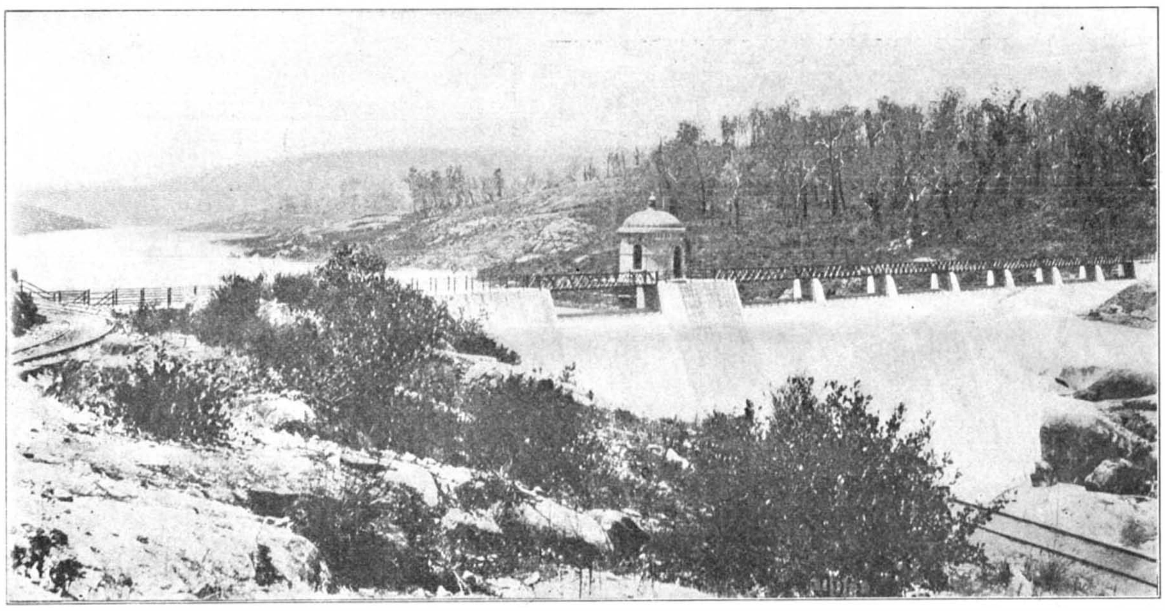
The government, as the gold-bearing reefs and mines developed, attempted, as far as possible, to mitigate the sufferings of the unfortunate miners. Tanks were excavated and dams were built at frequent intervals along the roads to the fields. At the

DAM IN COURSE OF CONSTRUCTION.

THE COOLGARDIE WATER WORKS.

lower levels of the mines salt water was found. So precious was it, that it was condensed and sold at $18 per 1,000 gallons. Yet the emergency was by no means met. Typhoid fever raged, and owing to the extreme brackishness of the water—there being 30 ounces of saline matter to the gallon—a quantity of the fine gold was lost.

In 1894 another difficulty arose. Owing to the success of the mines, the railroad had been extended from its previous terminus at Southern Cross to Coolgardie and Kalgoorlie. The railroad authorities, owing to the shortage of water, could not operate the traffic. The cost of water alone to the railroad department was $5,000 per day during the summer.



HELENA WEIR (BACK VIEW).

Under these circumstances it became incumbent on the government to devise some scheme for the supply of fresh water in unlimited quantities and at a normal price. Various schemes were suggested, and an endeavor was made to meet the difficulty by boring, but after descending 3,000 feet through granite this project was abandoned.

In 1895 the government decided upon a scheme for supplying water from the coast by pumping operations. The task of preparing the project was undertaken by the late Mr. C. Y. O'Connor, engineer-in-chief, in July, 1896. After several months' work and survey, the engineer advanced a scheme which comprised the erection of a reservoir on the Helena River near Mundaring in the Darling ranges, about 20 miles from Perth. Thence the water was to be pumped through a main to Coolgardie. In the first place, only 1,000,000 gallons was suggested as being sufficient, but this quantity was subsequently increased to 5,000,000 gallons per twenty-four hours. It was estimated that the cost of the project would approximate $12,500,000 exclusive of the reticulation of the towns *en route*. The bill was duly sanctioned by the government in 1898.

The main supply reservoir of this scheme is located in the Darling ranges, some 20 miles from Perth, at an elevation of 320 feet above sea level. At this point two great arms of granite jut out across the narrow valley at the bottom of which flows the Helena River. Avail was made of these natural side embankments, and a gigantic dam, like a huge wedge, was thrown across the river at this point between them, thereby closing up one end of the valley.

This barrage is 760 feet in length and 100 feet high at the deepest part. In order that it should be able to withstand the heavy back pressure of water, the foundations were carried down to a depth of nearly 100 feet below the level of the river. At the base of the foundations the thickness of the dam varies from 85 to 120 feet, tapering to a width of 15 feet on the top. It is built throughout of concrete, 69,000 cubic yards of which were used in its erection. The reservoir or lake thus formed behind this barrage measures eight miles in length, and contains when full 4,600,000,000 gallons of water of an exceptionally good quality. The catchment area consists of 850,000 acres, and comprises mostly granite hills.

For the conveyance of the water from the reservoir to the distribution area, 330 miles distant, a new and novel form of pipe known as Mepham Ferguson's patent locking bar pipe was adopted. This pipe consists of two steel plates rolled into semicircular form, the edges of which are upset by special machinery and a locking bar forced on. The joint is then finally clamped or closed by means of hydraulic machinery.

The diameter of the pumping mains is 30 inches, each pipe being about 28 feet in length and made of plates ¼ inch thick and weighing about 1¼ tons. In some sections, where there is extra pressure, the thickness of the plate is increased to 5-16 inch. The total number of pipes required for the undertaking numbered about 60,000 for the main to Coolgardie, representing a weight of about 76,000 tons, and a total value of $5,525,000. The whole of the pipes were manufactured in Western Australia by Messrs. Mepham Ferguson and Messrs. Hoskings Brothers, special plant being laid down for the purpose.

Each pipe was subjected to a hydraulic test of 400 pounds to the square inch. It was then immersed in a bath of Trinidad asphalt, and kept there until the steel rose to the same temperature as the bath itself. The coating of asphalt thus obtained acts as a preservative against rust, etc. The circumferential joint consisted of a forged steel sleeve with lead-calked joint. These joints were made by a specially-designed calking machine, which was electrically operated for a considerable portion of the time, but subsequently the electrical drive had to be abandoned in lieu of manual power, owing to the extreme difficulty in obtaining water for the engine. The lead joints, where the locking bar comes in, were calked by means of a small hydraulic press. An average of from twenty to thirty joints per working day of eight hours was accomplished by the machines. No expansion joints were used or found necessary. The pipes were partly laid in a trench, and then covered to a uniform thickness of two feet with soil, except at those places where salt country was encountered. Then, in order to avoid corrosion, the pipes were carried on trestles, and protected from the sun by a covering of corrugated iron on wood frames, with the intervening space packed with sawdust.

The success of this supply scheme depended entirely and absolutely upon mechanical means for the conveyance of the water from the main reservoir at Helena River to Coolgardie, and the selection of a suitable pumping and boiler installation constituted the most vital phase of the undertaking. The pumping requirements demanded were the pumping of 5,600,000 gallons of water per twenty-four hours against a total estimated head, including friction, of 2,700 feet through a pipe 30 inches in diameter, and roughly 330 miles in length, the speed of the water through the pipe being taken at about 2 feet per second. Throughout this 330 miles are located eight pumping stations. In each of the first four stations there are three complete sets of pumping machinery and boilers, any one of which is capable of pumping 2,800,000 gallons per twenty-four hours against a head of 450 feet, so that in order to obtain the full quantity of water two sets of engines and pumps are always pumping together into the main, with one set as spare. In each of the stations from No. 5 to No. 8 inclusive, there are two sets of machinery, each set being capable of pumping 5,600,000 gallons per twenty-four hours against a head of 225 feet, so that while one set is pumping, the other is in reserve.

The first station is situated close to the foot of the great dam on the Helena River. The water is elevated 421 feet in daily work into an open concrete tank with a capacity of 468,000 gallons situated at No. 2 station, the total distance from No. 1 being about 1½ miles. From No. 2 station the water is lifted about 360 feet through 23 miles of main to the first regulating tank at Baker's Hill, about 1,080 feet above sea level. This tank is of concrete, with a capacity of 500,000 gallons. The water gravitates from Baker's Hill to a second regulating 500,000-gallon concrete tank at Northam, 18 miles farther on, the Northam tank being 94 feet lower than that at Baker's Hill. Thence still falling, the water reaches the great tank at Cunderdin, 78 miles from the Helena reservoir, with a capacity of 10,000,000 gallons. Stations from No. 3 to No. 7 pump water against a steady rise to the eighth station at Dedari, a distance of 217 miles from Cunderdin, and situated at an elevation of 1,457 feet. Each of these stations is provided with a concrete tank of 1,000,000 gallons capacity, which act as combined receiving and suction tanks. From Dedari the water is pumped a distance of 12 miles to the main service reservoir at Bulla Bulling. This reservoir is of concrete, reinforced with barbed wire strands, and holds 12,000,000 gallons. Bulla Bulling supplies a small service reservoir of 1,000,000 gallons on Toork Hill, overlooking the town of Coolgardie, the mean elevation being 1,525 feet. The total head pumped against in daily working at stations Nos. 1 to 4 varies from 360 feet to 410 feet according to whether one or two engines are working. At stations Nos. 5 to 8 the head is from 180 to 210 feet. From Toorak tank the water gravitates to a reservoir on Mount Charlotte, which is the supply for the town of Kalgoorlie.

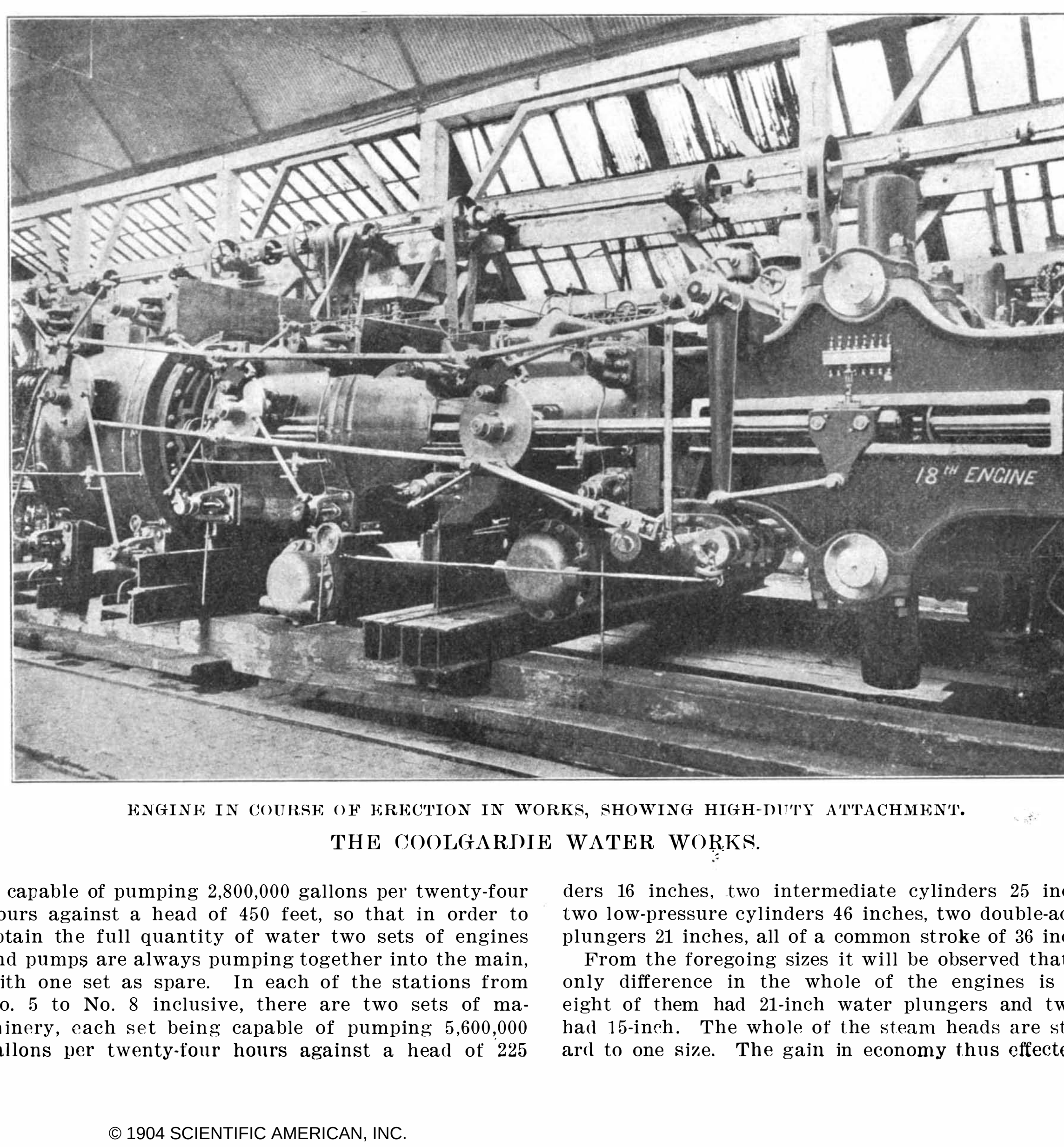
Owing to the heavy nature of this pumping requisition, the engineer-in-chief left the onus of submitting plans and proposals for the accomplishment of this severe undertaking to the various competing firms, he only laying down stringent tests of materials and workmanship, so that the possibility of the installation failing at any point was reduced to the minimum.

The contract was thrown open to the whole world, but was secured, after months of careful inquiry of the various submitted designs, by Messrs. James Simpson & Co., Ltd., of London, with special permission accorded to them to have half the manufacturing carried out by the Worthington Pump Company. The proposal of this firm, which has had wide experience in water-works engineering and pipe-line machinery in all parts of the world, was the installation of horizontal high-duty duplex direct-acting Worthington engines, which were guaranteed to give economical results in working.

The size and type of engine selected were as follows:

For stations 1 to 4 inclusive: Twelve triple-expansion high-duty Worthington pumping engines, each with two high-pressure cylinders 16 inches, two intermediate cylinders 25 inches, two low-pressure cylinders 46 inches, two double-acting plungers 15 inches, all of a common stroke of 36 inches.

And for stations 5 to 8 inclusive: Eight engines of similar type, each having two high-pressure cylinders 16 inches, two intermediate cylinders 25 inches, two low-pressure cylinders 46 inches, two double-acting plungers 21 inches, all of a common stroke of 36 inches.



ENGINE IN COURSE OF ERECTION IN WORKS, SHOWING HIGH-DUTY ATTACHMENT.

THE COOLGARDIE WATER WORKS.

From the foregoing sizes it will be observed that the only difference in the whole of the engines is that eight of them had 21-inch water plungers and twelve had 15-inch. The whole of the steam heads are standard to one size. The gain in economy thus effected is

at once apparent, as it means the whole of the twenty boilers, accessories, etc., are made standard, and the number of spare parts required to be held in store is greatly reduced.

The boilers are of the well-known Babcock & Wilcox water-tube type, with single drums equipped with superheaters; while in order to secure the highest possible economy, Webster feed heaters and Green's economizers with all necessary accessories are provided in the boiler house, one boiler for each engine being provided.

The steam ends of each engine comprise two 16-inch high-pressure cylinders, two 25-inch intermediate pressure cylinders, and two 46-inch low-pressure cylinders. The whole of these are jacketed with steam at boiler pressure, viz., 175 pounds per square inch, the cylinder covers being jacketed as well. The estimated indicated horse-power of each duplex engine is 300. The jackets are cast on the cylinders. The general arrangement of the rods is in accordance with the Worthington patents, the rods themselves being of Vickers-Maxim oil-toughened steel turned and then ground to size. The steam valves are rotative, of the Corliss type, and are driven by the Worthington patent high-duty valve-gear. Intermediate reheaters with steam at boiler pressure are used between the high-pressure cylinders and intermediate pressure cylinders, and the intermediate pressure cylinders and the low-pressure cylinders respectively. The air pumps are placed immediately below and between the steam and water ends of the engine, and are driven by means of links and levers from the crossheads.

The water ends are of the Worthington outside-packed plunger type, fitted with steel air vessel on the delivery, and cast-iron air vessel on the suction. The suction and delivery valves of the water ends are of the Worthington type with gun-metal seats, and the valves themselves are stamped out of the best manganese bronze. The condenser is placed on the suction, so that the whole of the water of the main passes through the condenser, and the volume is largely in excess of what is actually required; the temperature in the main is not raised to any appreciable extent.

The high efficiency of this type of Worthington engine is attained by the high-duty attachment with which it is provided, and which also forms an ample safeguard in the event of the delivery main bursting at any time. These engines have also been fitted with automatic braking apparatus, so arranged that when the pressure in the main falls below or rises above a prearranged limit, it immediately comes into action, and opens a valve on the exhaust pipe to the atmosphere, and the engine stops immediately.

The main pumps of each engine consist of two sets of double-acting plungers, working on the "Worthington cycle," i. e., one set of pumps is always delivering into the main, with the result that the delivery is most uniform, and shocks are entirely avoided, which insures an even flow of water through the mains.

The exhaust steam, on leaving the low-pressure cylinder, passes through a Webster oil separator, thence to an auxiliary feed-water heater of the tubular type, then through the condenser and air pumps to the feed-water tank.

An ingenious arrangement has been incorporated for using the jacket steam, which as it passes from the jackets is taken and used to drive the Worthington boiler pressure type feed pumps. These exhaust into the Webster feed-water heater. By this arrangement the feed water is sent forward from the Webster feed-water heater to the Green's economizer at a very high temperature.

One of the most important sections of the machinery, which conduces to the high working economy obtained, is the high-duty attachment. By means of this the excess of power exerted by the steam in the cylinders at the beginning of the stroke is stored up and transmitted to the end of the stroke, when the steam pressure, owing to expansion, is smallest. Owing to the high temperature of the steam used, viz., 500 deg. Fahr. approximate, the whole of the piston rods and valve spindles have been fitted with metallic packing.

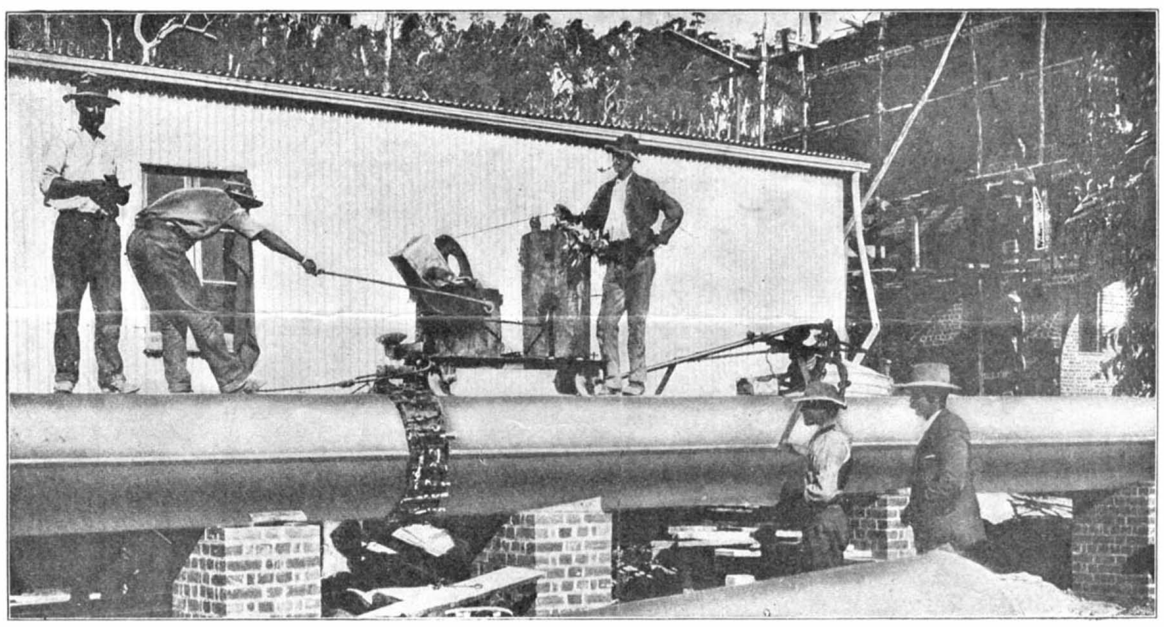
The engine and boiler houses are constructed of brick, and are equipped with overhead traveling cranes, which can be operated from the floor of the engine house. The cylinders, steam piping, and all parts liable to radiate heat are well covered with magnesia insulating material.

The contract with the West Australian government provided that each of the pumping engines should be capable of attaining throughout a 12-hour trial a duty of 135,000,000 foot-pounds of effective work per 1,000,000 British thermal units supplied to the engine, which would not be returned to the boiler in the ordinary course of working. It also provided that, for the purpose of testing the combined working duty of the pumping engines and boilers, two groups of machinery at one of the first four stations, and one group of machinery at one of the second four stations, should be capable of pumping through the main to the next reservoir not less than 2,800,000 imperial gallons of water during a 12-hour trial; and that the combined duty of the group should throughout such trial amount at least to 135,000,000 foot-pounds of effective work for every 160 pounds of coal consumed, such coal being equal to a fair sample of good Collie (West Australia) coal, having a calorific value of 10,000 British thermal units per pound.

The government engineer for the Coolgardie water supply selected a group of machinery at the No. 2 pumping station and at the No. 8 pumping station respectively for the purposes of running the official trials. At the former of the selected stations the trial resulted in a duty of 142,093,598 foot-pounds of work being obtained per 1,000,000 British thermal units, showing a margin of 7,093,598 foot-pounds of work in favor of the engines. The working duty trial resulted in a duty of 144,427,000 foot-pounds of work being obtained for each 160 pounds of coal consumed, showing a margin of 9,427,000 foot-pounds in favor of the engines. The amount of water pumped during the 12 hours by the two groups of machinery was 2,998,081 gallons—an excess of 198,081 gallons.

At the second selected station the trial resulted in a duty of 142,934,958 foot-pounds of work being obtained per 1,000,000 British thermal units, showing a margin of 7,934,958 foot-pounds of work in favor of the engines. The working duty trial resulted in a duty of 148,141,000 foot-pounds of work being obtained for each 160 pounds of coal consumed, showing a margin of 13,141,000 foot-pounds in favor of the engines. The quantity of water pumped by the engines during the 12 hours was 3,147,559 gallons, showing an excess of 347,559 gallons over the contract delivery.

The time allowed, according to the contract, was twenty-seven months for the supply, erection, and delivery in working order of the complete pumping plant. In order to meet such conditions, the installation of the machinery was carried out simultaneously at the eight stations. It was unfortunate that the engineer-in-chief, Mr. O'Connor, did not live to see the realization of his huge engineering project, which has brought such welcome relief to a waterless district. The scheme has been in operation for several months now, and is working with perfect success and satisfaction, and has solved the problem which for so many years appeared insurmountable.



RUNNING LEAD INTO JOINTS.

THE COOLGARDIE WATER WORKS.

SIBERIA AND THE TRANS-SIBERIAN RAILWAY.

ANNALES DES SCIENCES POLITIQUES, in its issue of September 15, says that the construction of the Trans-Siberian Railway was undertaken mainly to develop the resources of Siberia, although there were political and strategical reasons also.

In 1857 an American named Collins first proposed a railway from Amur to the village of Tchita. Later, several plans were formulated, but it was not until March 17, 1891, that the Trans-Siberian Railway was definitely determined on and projected by an imperial order. On May 19, 1891, the first stone was laid. The line covers 3,562 miles in Russian territory and 1,604 miles in Chinese territory. In ten and one-half years 5,166 miles of rails were laid. In the Canadian Pacific, constructed under similar conditions, it took ten years to lay 2,921 miles of rails. It is true that in order to construct the Trans-Siberian with such rapidity it was necessary to employ simpler means than those usually employed on Russian railways. Lighter rails were used; less ballast was put under the ties; the ties were shorter; fills, instead of being made 18 feet wide, were limited to 16.4 feet; and the grades and curves were accentuated. The government thought thus to reduce expenses, but it was quickly perceived that this would not answer the exigencies of the case. The government therefore proceeded immediately to replace the light rails, to lengthen the ties, and to perfect the roadbed. This, of course, meant double work and a corresponding increase of expenses.

Freight trains cover the distance from Moscow to Vladivostock in fifty to sixty days, traveling at the rate of about 8 miles an hour; passenger trains make a speed of about 13½ miles an hour. It is hoped that when the road has been perfected the freight trains will make 13½ miles an hour and passenger trains 22 miles. The total expenses to date exceed $391,400,000. There are yet two lines to be completed—one around Lake Baikal and the other to Khabarovsk.

Before the construction of the railway the commerce of Siberia with Russia passed almost entirely through the two towns of Toura and Tioumen. In 1891 there were exported from Toura 87,662 tons of Siberian products, and 41,565 tons imported from Russia; 80 per cent of the exports were cereals. From 1896, the commencement of regular traffic on the railway, until 1899 the number of travelers transported had increased from 417,000 to 1,075,000, and the number of tons of merchandise transported had increased from 206,452 tons to 728,939 tons, but it must be remembered that these figures include some goods destined for the railroad and for the state. The products exported are cereals, tea, beef, pork, butter, leather, hides, wood, salt, wool, eggs, game, cattle, poultry, charcoal, and cedar nuts.

By means of the Trans-Siberian Railroad, a regular communication has been established with the different rivers of Siberia, and this is particularly important for the movement of cereals, since 365,887 tons, or one-half of the total exports, were cereals.

This railroad has rendered the most appreciable services to the colonization of Siberia. This colonization has been aided by the creation of a "trans-Siberian committee," which sent out literature on Siberia and also established a number of supply houses and medical depots. The efficacy of the latter may be judged from the mortality figures of the emigrants *en route*—in 1894, out of 56,000, 3,000 died, while in 1899, out of 220,000, only 300 perished. From 1893 until 1899 the number of emigrants increased from 65,000 to 223,918, while the total number amounted to 968,440. The fare for emigrants is one-fourth of the regular rate. In 1900 a special commission was formed for the purpose of laying off lots for the colonists; since that time 15,506,997 acres have been laid out and 11,629,707 acres are now occupied. Every emigrant with the proper authorization receives 40.5 acres. During the first three years of residence the emigrant pays no taxes, and for the three following years he pays only one-half the legal rate. Emigrants without resources are furnished money for expenses of travel, etc. Wood is furnished them from the imperial forests. At localities where wood can not be obtained direct from the forests, depots have been established where it can be obtained at first cost.

The average annual crop of Siberia amounts to from 3,280,000 to 4,100,000 tons, of which three-fourths come from western Siberia.

It is also interesting to note the development of the commercial relations of Siberia and Japan. From 1896 until 1900 the imports from Japan had increased from $86,440 to $1,763,418. During the same period the exports had increased from $656,000 to $2,846,568.

THE NON-METALLIC MINERAL PRODUCTS OF THE UNITED STATES.

SOME surprising figures are given by Mr. Edwin C. Eckel in an article on this subject in the Mining Magazine. He says that the value of the total mineral production of the United States for 1902, the latest year for which complete statistics are available, was $1,259,639,415. Of this enormous value $642,258,584 was contributed by the metals, and $617,380,831 by the non-metallic mineral products. If these figures could be accepted as a just valuation of the relative commercial importance of the two classes, it would appear that the metals had contributed 51 per cent, and the non-metals 49 per cent of the total.

If the values were based on the same condition of product in both cases—either on the value of the mineral as mined or on the value of the finished product—it is probable that the non-metallic minerals would be found to contribute at least 75 per cent of the total mineral production of the United States.

From the point of view of human comfort, the disparity in importance is just as striking. We could contemplate, with some serenity, the possibility of having to live without copper—but not the necessity of existing without salt. A scarcity of gold is certainly inconvenient, but not to be compared for discomfort to a lack of fuel. With the single exception of iron, the metallic products are objects of convenience, while many of the non-metals are necessaries of civilized life.

He gives the following figures covering the non-me-

tallic minerals, grouped according to the uses to which they are put:

	Value, 1902.
Fuels	$469,078,647
Structural materials	95,249,255
Road-making materials	14,901,443
Chemical industries	9,389,741
Mineral waters	8,793,761
Fluxes	5,543,084
Mineral paints	5,170,689
Fertilizers	4,812,422
Abrasives	1,326,755
Refractory materials	846,881
Minor non-metals	2,268,153

Speaking of the marvelous growth of the American Portland cement industry, Mr. Eckel says that the gold production of Cripple Creek is parallel to and only slightly above that for Portland cement, while the production of Alaska sinks into comparative insignificance. It will be seen that the most surprising part of this increase in the cement industry has been within the past eight years. A Portland cement production valued at about $2,500,000 in 1896 has risen to over $22,000,000 in 1903.

THERMO-ELECTRIC RECEIVERS FOR WIRELESS TELEGRAPHY AND TELEPHONY.*

By the Belgian Correspondent of the SCIENTIFIC AMERICAN.

PROF. ANDRÉ BLONDEL, it will be remembered, some time ago made known some methods of transmitting and receiving wireless telegraphy signals that permitted of the use of the selective telephone, and that were based upon the employment of wave-detecting apparatus which do not require to be struck in order that they may instantaneously recover their primitive state after the passage of the waves. More recently, Prof. Blondel has devised some new and interesting arrangements of which we purpose to give a brief description. The principal elements of these is a wave-detector based upon the properties of thermo-electric couples, and which may be combined with any kind of telephone, or with a selective one when acoustic selection is desired. Apropos of this, we shall describe a selective telephone which is simpler than those known up to the present, and which also is of Prof. Blondel's invention. The accompanying figures represent these new apparatus diagrammatically and show the method of using them.

Fig. 1 shows the principle of construction of the wave-detector, which is formed of a thermo-electric couple consisting of very fine wire placed in a vacuum tube and traversed by the current to be detected.

Fig. 2 shows the simplest method of connecting up such a wave detector. Figs. 3 and 4 show the method of connecting up the wave detector in the most complicated cases, when the receiving wire is made to act upon the wave-detector through induction and not directly.

Figs. 5, 6, and 7 represent, diagrammatically, the arrangement of a selective telephone capable of being advantageously employed with the same wave detector described, in the particular case in which it is desired to separate, upon their arrival, the waves coming from various transmitting stations.

Fig. 8 shows a variant of the detector illustrated in Fig. 1, and in which the current passes not between *a* and *b*, but in an auxiliary wire, *d e*, secured to the two others at their point of attachment, *c*.

Construction and Operation.—Up to the present it has been found impossible to utilize thermo-electric couples for the reception of electric waves, doubtless because of the want of adequate sensitiveness, although such couples have been employed in laboratory experiments, especially by Rubens, Lindemann, and others.

In order to obtain great sensitiveness, Prof. Blondel prefers to cause the waves, or the oscillating currents induced by them, to pass through the wire of the couple. He employs very fine wires and places them in a vacuum in order to reduce radiation. Fig. 1 shows an example of the manner in which such a detector may be constructed. In the tube, *t*, in which the vacuum is formed, are placed two electrodes, *a* and *b*, connected with the circuit by rods welded in the glass and presenting a calorific capacity such as to prevent sensible heating during the passage of the current. To these electrodes are soldered two very fine wires, *ac* and *cb*, formed of different metals, presenting a notable thermo-electric effect, and soldered together at their common extremity, *c*. The wires that give the best results are, for example, those of iron and constantan reduced to an extremely small diameter (less than 1-100 of a millimeter), by ordinary methods, especially by attacking very fine drawn wires with an acid. The soldering at the point *c* may be done, say, by means of a drop of tin or of a soldering alloy, or else through the preliminary passage of an electric current of sufficient tension to effect the cohesion of the wires brought into contact. Prof. Blondel employs also another form of tubes (Fig. 8) more analogous to the thermo-electric couples already known in the study of oscillations, viz., a wire, *d e*, traversed by the current and heating the joint *c* of a couple *a c b*, but which offers the advantage of being placed in a vacuum and connected with the telephone. The vacuum tube containing the wires may be silvered so as to still further reduce the heat of the thermo-electric couple.

The wires of the thermo-electric couple are as a general thing shorter than they are represented in Fig. 1. Their length is proportional to the energy that may be expended therein for the reception. When the signals are too short, the heat at the joint has no time to extend to the electrodes.

When the tube is submitted to an oscillating current traversing the thermo-electric couple, *a c* and *b c* (or *d c* and *e c*), these wires become heated, and the point *c* is kept at a higher temperature than the extremities, *a* and *b*, which are constantly cooled by contact with the electrodes to which they are soldered. An electromotive force is then set up and may be detected by a sensitive telephone mounted in series or in shunt with the wave detector.

It is possible, for example, to place this telephone, *M*, in shunt with the detector, *V*, mounted in series between the receiving wire, *A*, and a large capacity *T*, which may be a metallic plate or the earth itself. Every passage of the electric waves that gives rise to an electromotive force in the tube, *V*, will produce a slight sound in the telephone as a consequence of the current that such an electromotive force produces in the closed circuit, *Vs M*. In order to more effectively cause the waves to pass into the tube, *V*, a self-induction coil, *s*, may be interposed in the shunt circuit of the telephone.

Since the resistance of the thermo-electric couple is very great, the action of the waves thus directly applied according to the diagram shown in Fig. 2 may become weakened. At all events, it is limited by the weakness of the electromotive force produced in the radio-receiver, *A*, and which is generally less than one volt. In order to obtain the most advantage from the energy received by the receiver, *A*, it is therefore well, as a general thing, to raise the tension acting upon the tube, *V*, by means of a transformer. Such is the object of the arrangement shown in Fig. 3, and in which *J* represents a small transformer of the kind devised by Marconi and other inventors. The primary circuit is connected in series with the radio-conductor, *A*, while the secondary one acts upon a closed circuit containing the detector, *V*, and the telephone, *M*. In this case, the induced currents traverse the telephone, while at the same time, the tube *V*, under the effect of the heating, produces an electro-motive force of constant direction dependent upon the thermo-electric properties of the metals employed for forming the couple. This electromotive force appears during the passage of the waves and afterward disappears. It therefore makes its action felt chiefly upon the telephone. It is of interest, nevertheless, in order to combine in the telephone the effect of the thermo-electric couple and that direct from the waves, when the oscillations produced in the radio-receiver, *A*, are choked to make the direction of the initial induced current the same as that of the current produced by the tube, *V*, because the electro-motive force of the first oscillation is generally preponderant with respect to the following choked oscillations.

It is possible also to place the tube, *V*, not in series in the secondary circuit of the transformer, but in shunt, as indicated in Fig. 4, by adding, if desired, as in Fig. 1, a self-induction coil, *s*, in the shunt branch containing the telephone. The operation will then be the same as in the case shown in Fig. 8, with the sole difference that the tension will be increased by the use of the transformer.

Instead of a transformer, it is possible to employ a simple multiplier of the kind utilized by Slaby. Fig. 5 gives an example of this in which it may be seen that the multiplier, *Z*, is traversed in part by the oscillating current of the receiving wire, *A*, and that the extremities are put in circuit with the tube, *V*, which acts upon the telephone in the same manner as in Fig. 3 or in Fig. 4.

The dotted lines in Figs. 3, 4, and 5 indicate that it is possible to connect a condenser, *C*, in shunt upon the telephone, *M*, or upon the tube, *V*, in order to facilitate the passage of the oscillations in the receiving circuit. It is possible, also, to put condensers in series with *M*.

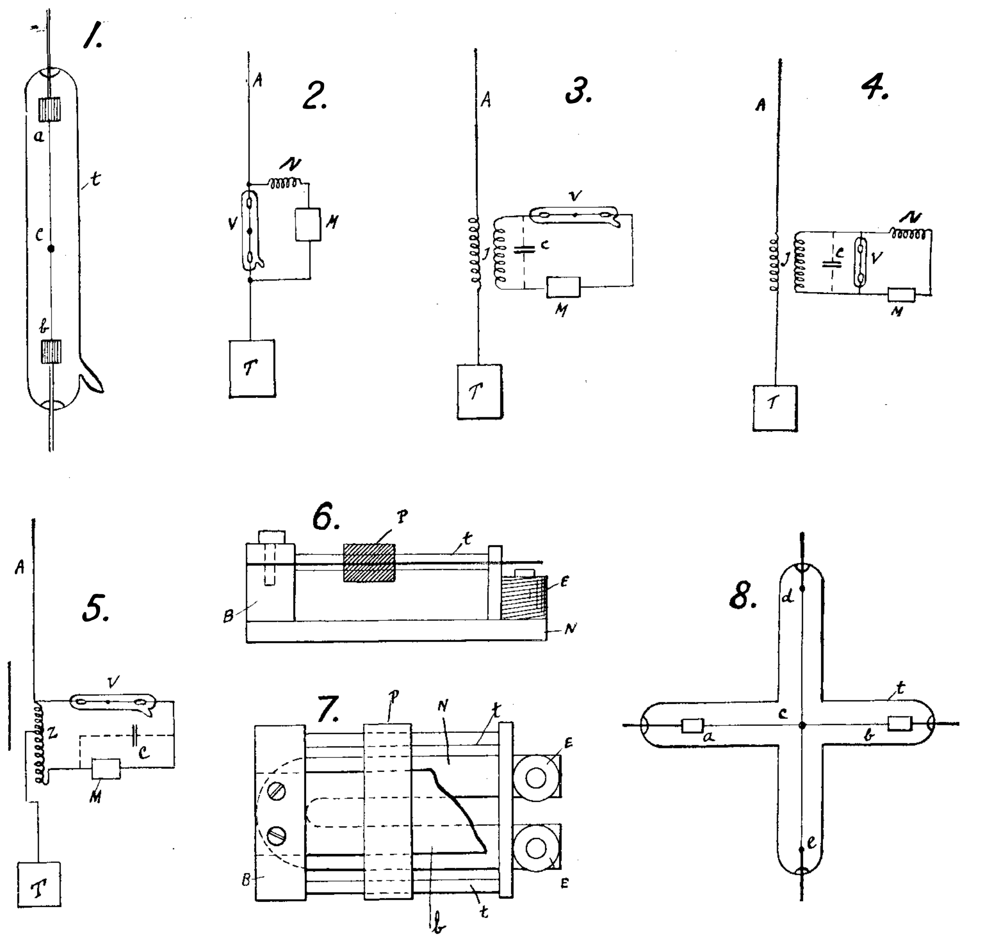
More generally, the local circuit in which the tube, *V*, is placed, may be put in electric resonance with the waves received by the addition of condensers or resonators according to any of the arrangements employed for producing resonance. It suffices, in fact, to replace the ordinary wave-detectors by the new detector, employed according to the general principles described, in all ordinary receiving installations or in all that might be devised for the circuits of receiving stations.

In the selection of the signals coming from transmitting stations that give different sounds, the Blondel receiver may be employed with monotelephones that select certain sounds by reinforcement. Upon studying this latter application of the new detector, Prof. Blondel has been led to improve selective telephones in such a way as to render the putting of these more rapidly in acoustic resonance with the sound of transmitting stations.

Up to the present, mono-telephones or selective telephones have been apparatus regulated once for all to contain frequencies of vibration which cannot be modified while the instruments are in use. The result of this is that if it be desired to receive signals from several stations, the same number of selective telephones is necessary. A still greater drawback is that if the sounds of the transmitting stations do not accurately preserve the same frequency, the selective telephone can no longer be in resonance with the station for which it was constructed. In order to obviate such inconveniences, Prof. Blondel has constructed the telephone in such a way that its regular frequency of resonance may be modified at will. For this purpose (see vertical section in Fig. 6 and plan in Fig. 7), Prof. Blondel employs as a vibrating plate a sheet of iron or steel, *b*, of rectangular form set into a support, *B*, at one end and having its free end at the right submitted to the attraction of one or more electro-magnets, *E*. Along this plate may be displaced a clamp, *P*, which, while grasping it, slides straight along stationary rods, *t*, and thus limits the vibrating portion of the plate to the length situated on the right of the clamp. The number of vibrations of a plate thus arranged varies, as we know, in the inverse ratio to the square of its length. It is, therefore, possible, by giving the clamp, *P*, a continuous motion, to cause a variation, at will, in the sound proper to the plate until it is in resonance with that of the vibrations of the transmitting station. The thickness of the plate is modified as need be by replacing it with another.

It is possible to reinforce the action of the electro-magnets, *E*, by means of a permanent magnet, *N*, to which they are secured according to the known principles of ordinary telephones, and of which the diagram gives an example. But it is unnecessary to say that a large number of effective variants are possible for the arrangement of this telephonic apparatus, and the diagram and short description that we give of them are designed merely to indicate their general principle.

As may be seen, the Blondel receiver approaches that of Fessenden, while, at the same time, it noticeably differs from it. In the Fessenden, as in the Blondel apparatus, the energy of the waves is converted into heat; but in the Fessenden apparatus, the heat, by causing a variation in the resistance of the receiving circuit, and through it a variation in the current that traverses the telephone, permits a sound to be heard in the latter, while in the Blondel apparatus, the current, or rather the heat that it produces, is directly



THERMO-ELECTRIC RECEIVERS FOR WIRELESS SIGNALING.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

utilized for generating the current necessary for actuating the telephone by means of a special thermo-electric battery.

Which of the two systems is preferable, it is difficult to say, and experience alone will decide. Both are remarkable by their simplicity, and by the absence of coherer arrangements. That of Prof. Blondel is remarkable by the absence of a battery—a great advantage over the Fessenden receiver. But, on the contrary, will the Blondel receiver have the constancy of operation and the sensitiveness that may be attributed, *a priori*, to the Fessenden receiver? Doubtless it will if Prof. Blondel succeeds in constructing a special thermo-electric battery different from all others, whose main defect seems to be exactly that of not being constant. Whether he will succeed in doing so or not is the question.

DO THE RAILS OF ELECTRIC STREET RAILWAYS RETURN THE CURRENT TO THE GENERATING STATION, OR SIMPLY ACT AS A GROUND?*

THE RESULTS OF ORIGINAL EXPERIMENTS BY EMILE GUARINI.

As a professional man, I am led to propound the following question: "What is the influence of an electric tramway line, and especially of the rails through which the current returns to the generating station, upon a relay formed of a magnetized needle capable of revolving in a vertical plane, and dipping, at the time of the deflection, into mercury cups in which ends the local current, such a relay being placed, in ordinary practice, a few inches from the ground?"

As two trolley lines pass within a few yards of my house, all the observations which follow were extremely easy to make. The relay was regulated in such a way as to operate with certainty when it was placed parallel with a rail through which a current of 6 amperes was flowing, this having been determined by experimenting with the rails of a steam railroad track. (See Figs. 1 and 2.)

When I began testing the trolley line, I found to my great astonishment that the relay did not operate except when the train was but a few yards only from my apparatus. If we consider: (1) that the line was 7¼ miles long, and that there were always several cars running at once; (2) that the line had very heavy gradients, and that consequently the intensity of the current for each car amounted to upward of 100 amperes; (3) that the action of the two rails, which were in multiple, was directed upon the apparatus; (4) that the counteracting action of the current (Fig. 3) traversing the trolley wire was much less than that of the currents in the rails because of the considerably greater distance of the apparatus from the wire; (5) that, moreover, the relay was also put in such positions that the action of the current in the trolley wire was necessarily added to that in the rails; and (6) that the relay was tested at every instant with a magnet, the phenomenon might seem very strange.

The idea occurred to me that, since at the place at which I experimented, there were two tracks, the sections were supplied in such a way that the actions of the currents of the two tracks counteracted each other (Fig. 4).

Although it would have been easy to assure myself of this on the spot, I preferred to transfer my experiments to a neighboring avenue in which there was but one track. The results were absolutely identical. What was still more astonishing was that at the very instant at which a car was passing the place where the apparatus was located, the relay did not operate. Of this I found the explanation subsequently.

The conclusion that I drew from these observed facts was that the rails serve as a ground merely and not as a return conductor for the current. This view has been confirmed by a series of experiments that I recently performed. In these I did not employ the relays already described (Fig. 5) in which the whole was mounted in a copper box filled with paraffine oil, but a simple magnetized needle capable of revolving in a vertical plane (Fig. 6), and sensitive enough to dip as far as possible when it was placed at from 5 to 7 centimeters from a rail through which a current of about 3 to 4 amperes was flowing. These experiments were made upon a single track. Contrary to what occurred in my first experiments, it was here possible to observe the slightest motions of the needle.

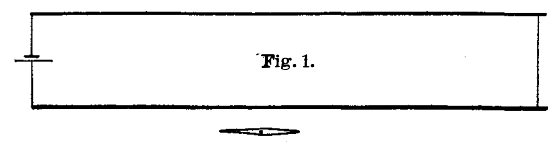
The following are the results of my observations: When there was no car in the vicinity, although there were several at a distance on each side of the needle, the latter remained absolutely horizontal and gave no evidence of any current in the rails.

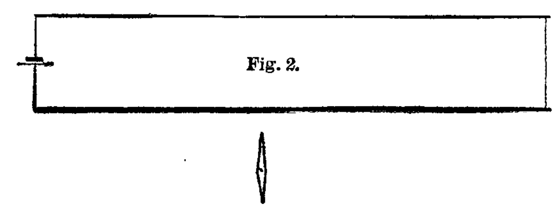
When a car arrived on the track on which I operated (in Avenue Michel-Ange, in which the cars came only in a single direction), the needle began to deviate, and the deviation increased in proportion with the approach of the car, being almost an indicator of the movement of the car. At the moment at which the car was passing near the apparatus, the needle returned to zero and then deviated anew to its maximum and very gently returned to its horizontal position when the car was at a distance of barely 250 yards. This phenomenon would be inexplicable in case the current returned to the power house, which was beyond the apparatus, since in such an event the current and the deviation of the needle would, in the first place, be much greater, and, in the second, would not annul each other in measure as the car got farther away. Besides, the needle ought not to deviate when the car is situated between the power house and the needle.

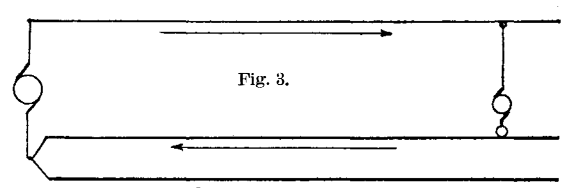
A counter-experiment has further convinced me that the rails perform no other part than that of a ground. If, in fact, this is so, the following is what ought to occur: The power house is at *A*, and the apparatus at *B*. When the car is beyond *B* (Fig. 7), the current becomes dispersed in the ground in all directions and especially through the rails. With respect to the apparatus, *B*, the current proceeds from *A* toward *N*. The needle should therefore deviate in a determinate direction. When, on the contrary, the car is at *B*, the current is divided in the two directions and the action upon the needle should be null (Fig. 8). The following is what the experiment demonstrates: At the approach of a car the needle deviates in a certain direction. When it is *in situ* the needle is horizontal, and when the car moves away the needle deviates in an opposite direction, and this proves beyond a shadow of a doubt that, at least when they are in perfect contact with the earth, the rails serve as grounds, which, in my case, concerned but 820 feet of track.

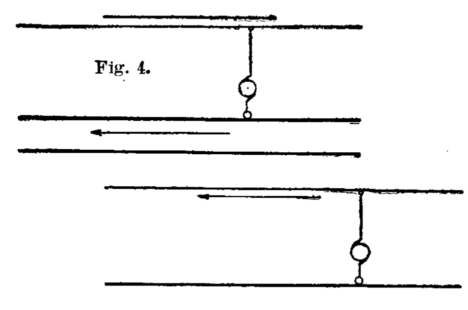
This matter has not a simple theoretical bearing, but will have a far practical reach. The first objection that may be made to my views is the following: But then it is useless to bond the rails electrically, to spend from $0.50 to $1 per joint, in order not to have a resistance greater than 2-100 to 5-100 of an ohm. This is not so, however, for experiment has demonstrated from the very beginning of trolley traction, that in rails that are not bonded the losses are considerable.

In fact, if the rails are not bonded electrically, the









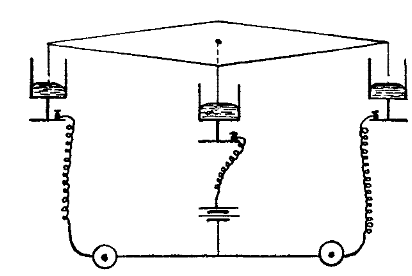
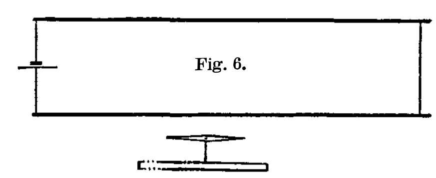
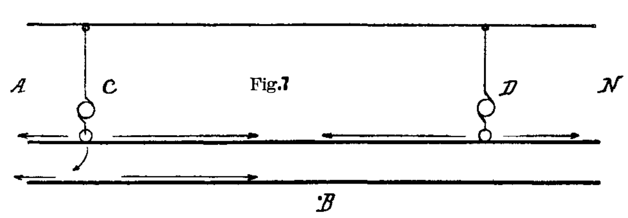
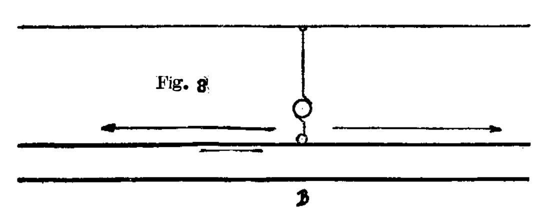


Fig. 5.







car will at every instant have as a ground only the rails with which its wheels are in contact, say 2 or 4 at once. That would prove a bad ground having sometimes an appreciable resistance of several ohms, and even several score of ohms, and would cause the losses with which we are familiar. When, on the contrary, the rails are bonded, we have a ground constituted by a sufficient number of rails—in my case, 820 feet on each side of the car.

From this, there results a very important consequence. In a case where the return to the power house was through a track 15½ miles long (25,000 meters), we would have to give the joints a very slight resistance, since the losses would be considerable with a line of this length comprising about 5,000 joints (two series of 2,500 in multiple). But in the case in which the rails serve merely as a ground, there would be needed, let us suppose, 825 feet of track. (There are twice 820 feet of rails that serve as a ground, and, in the case of a double track, there would be four times 820 feet of rails in multiple, supposing that the two tracks are connected). This means that, for a determinate loss tolerated, we may have joints that are less conductive and that cost less. In the lines already installed, we have, as a consequence, less of a loss in the rails than might be supposed.

*Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

White Metal Alloys.—Melt together either 65 parts of copper and 55 parts of arsenic, or 64 parts of copper and 50 parts of arsenic, or 10 parts of copper, 20 parts of zinc, and 30 parts of nickel, or 70 parts of nickel, 30 parts of copper, and 20 parts of zinc, or 60 parts of nickel, 30 parts of copper, and 30 parts of zinc.

PROTECTION OF TREASURE BY ELECTRICITY.

ONE of the greatest stores of treasure in the world is contained in the vaults of the United States government at Washington. In the Treasury Building, as it is called, a large quantity of the paper-money of the country is completed and prepared for circulation; but in addition to this, notes which are issued by the national banks in exchange for bonds of the United States are stored in a compartment which contains literally over a million dollars' worth of them. At all times the quantity of gold and silver coin of various denominations is so great that its weight represents several tons. The silver is kept in a number of vaults, but the supply of gold coin is divided between two compartments.

To protect the treasure from robbery, the government has employed a force of armed watchmen, a number of whom are continually on duty. Each man is assigned to a certain patrol. Every time he makes the circuit he presses the lever of an instrument which records his movements and the time when the lever is pressed. This is called the watchman's time-detector, and is used to keep a *check*, as it might be called, upon his movements; but, in addition to the watchman, the doors leading to the treasure-rooms are fastened with locks which can only be opened at a certain hour. They are called time-locks for the reason that they are provided with clockwork which is set to permit the bolts to be thrown back only at stated intervals.

Although no robbery has ever occurred at the Treasury except through employees, the authorities have decided upon a different means of protection, and have completed a system by which the electric current is the principal safeguard. Experts say that it would be absolutely impossible for a person to touch one of the doors or the inside surface of the walls of the vaults without an alarm being given at the various police stations of the city as well as the guard-room of the Treasury, so effectual is the safeguard devised. It is arranged in this way: The inside of the vaults were first lined with hardwood compactly joined at every corner. Upon the outer surface of the wood was laid a thin coating of what is known as tinfoil, which is one of the best conductors of electricity known. To the tinfoil was attached what would appear to the ordinary observer to be very fine netting composed of wire of a very small mesh and polished until it appeared as if plated with silver. The ends of the wire were carefully joined together with solder, which is known to be another excellent conductor of the electric current. Over the netting another lining of wood and tinfoil was placed, so that it is thoroughly protected from the air as well as from the possibility of any one tampering with it.

Thus not only the walls, but the floor and ceiling of each vault have been completely enmeshed with wire. To the netting is connected what is called a feed-wire, the whole being so arranged as to form a perfect electric circuit. The feed-wire extends to the power station in the building, and by its means an alternating current of electricity is transmitted through the network, the current being varied three times in every interval of five minutes; consequently the treasure is practically surrounded by what might be called a sheet of electricity. But the conductors are so delicately arranged that, as already stated, if one merely touches the woodwork on the inside of the vault, or at-

tempts to open one of the doors during hours when the vaults are intended to be closed, an alarm is given so quickly that the watchmen could reach the place from which it was sent within actually less than two minutes from the guard-house. Each vault is provided with duplicate alarm to avoid any possibility of one becoming disarranged and failing to perform its duty. If for any reason the electric current should be cut off, this is also announced automatically in the guard-house, the police stations, and in the engineer's room of the power station. With the electrical system the treasure will be protected by three methods: the watchmen (who will continue to be employed), the time-locks, and this invisible monitor.

The vaults at the Treasury are considered among the best ever made for the protection of treasure; but robberies of banks which have recently occurred in the States show that burglars have tools with which they can successfully penetrate the hardest steel. Actually, orifices no larger than the size of a pin-hole have been large enough to allow of the insertion of the points of tools with which the metal can be bored, and a charge of explosive inserted, thus forcing open the side or door. Successful robberies have occurred where nitroglycerine has been forced into a tiny crack with an air-pump and then ignited. Recently, however, electricity has been used with remarkable effect upon vaults composed of the heaviest steel. It was a test of this kind which so alarmed the government representatives that they finally decided upon using the same force to protect the treasure. An experiment was made with a safe-opening device which merely consisted of a coil of wire, an electrical socket, and a point composed of carbon. The expert in charge of the test connected the wire with that furnishing the lighting current in one of the Treasury apartments, fastening the socket in place of one of the incandescent lamps. Turning on the current, he applied the carbon point to the surface of the mass of steel on which the experiment was to be made. Within twenty minutes the heat had melted a hole through the metal to a depth of over three inches—a space large enough for the insertion of the hand and wrist without difficulty. Had the steel formed the door of a vault, the hole could have been made beside the lock and the latter removed or broken on the inside so as to allow the bolts to be withdrawn immediately.

[Concluded from SUPPLEMENT No. 1505, page 24112.]

RECOIL.—II.

By Brigadier-General J. P. FARLEY, U.S.A.

LET us next turn to a very interesting feature of this subject; that is, as relates to the effect of the force of the powder gases upon the molecular structure of the system—as to the vibrations in the barrel and the buckling which cause the *angle of departure* to alter from its original direction as set or placed by the firer and before the projectile leaves the bore of the gun. In this connection our reasoning will be confined to the case of a small arm. The writer discovered in the course of experiments made by him as long ago as November, 1874, that in proportion with the increase of powder charge from 10 grains and up to the standard 70-grain charge, the service 0.45 caliber carbine would for short ranges place its ball higher on the target for the least charge than for the greatest, and for intermediate charges at intermediate positions; contrary to the law of physics which instructs that for the shortest time of flight there should be the least drop of projectile. The Spirit of the Times, New York, under date of April 13, 1878, announced this same discovery and spoke of "the astonishment which was created at the armory rifle practice of the National Guard of the State of New York, a year or so ago, when it was found that shells loaded with 35 grains of powder, at 150 feet, shot six inches higher than those loaded with 70 grains." Then the theory of Mr. W. E. Metford, C.E., was exploited, which was identical with that of the writer's official report dated from the Armory at Springfield, March, 1875, and promulgated in Ordnance Notes August 15, 1878, to establish priority of claim for a discovery and investigation which had leaked out through the marksmen from the Armory in their practice at Creedmoor.

This investigation showed several things, chief among which was that there were *no vibrations* in the barrel calculated to derange the angle of departure of a projectile, greater than seventy-five ten-thousandths of an inch, before the projectile left the muzzle; but it was shown that when the gun was placed in a rest and clamped in front of its center of gravity, the vertical deviation from the point aimed at was 2.3 inches to 6.24 inches above, while when clamped in rear of the center of gravity, or at its butt, it was 4 inches to 8.6 inches below, and in offhand practice from the shoulder for the same sighting it was 6.19 inches to 29 inches below.

When, however, the gun was locked front and rear in the fixed rest, the vertical deviation from the same point sighted was zero.

General W. B. Franklin, vice-president of the Colt's Arms Manufacturing Company, suggested to the writer, when in the course of these experiments, that possibly the checking of the recoil of the gun added to the velocity of projectile and caused it to hold up better, to require less elevation, in other words, than where there was free recoil. With a view of ascertaining the correctness or incorrectness of this theory, a general and simple formula was evolved from the general relation $Ps = \frac{1}{2} MV_1^2 + \frac{1}{2} mv^2$, which furnished the necessary requirements for the determination of loss or gain in velocity of projectile due to free or restrained recoil.

Let us consider the problem from the standpoint of *muzzle* velocity of projectile, and disregard the action of the gas after the projectile has left the bore of the gun. Also for the sake of simplification disregard the weight of the powder charge moving forward with the projectile in its partially burned state.

We may then take, as General Franklin's engineer (Mr. Francis) has done, the formula

$$MV_1 = mv$$

expressing as it does the motion of the gun and projectile, both being acted upon by a force P over a path or barrel length.

P = force employed.
M = mass of gun.
m = mass of projectile.
V_1 = velocity of gun (feet second).
v = velocity of projectile (feet second).
s = length of bore over which gas acts.
S_1 = space due to velocity in one second.
t = time of motion of mass while the system remains connected.
n = ratio of mass of gun to mass of projectile.

$$mv = MV_1 = Pt \quad \ldots\ldots (1)$$

$$mv = mnV_1 = Pt$$

$$t = \frac{mv}{P} = \frac{mnV_1}{P} \quad \ldots\ldots (2)$$

$$V_1 = \frac{mv}{mn} = \frac{v}{n} \quad \ldots\ldots (3)$$

$$S_1 = \frac{v + V_1}{2} \times {}'' 1 \text{. sec} \quad \ldots\ldots (4)$$

Substitute for V_1, $\frac{v}{n}$ equation (3)

$$S_1 = \frac{\frac{v}{n} + v}{2} \times {}'' 1 \text{. sec.}$$

$$S_1 = st = \frac{(v + vn)\,t}{2\,n} = vt\left(\frac{n+1}{2\,n}\right) \quad \ldots\ldots (5)$$

Substituting value t from equation (2)

we have $s = V^2 \frac{m}{n}\left(\frac{n+1}{2\,P}\right)$

$$2\,Psn = V^2 m\,(n+1)$$

$$(6) \qquad V^2 = \frac{2\,Ps}{m} \times \frac{n}{n+1} = C \times \frac{n}{n+1} \qquad (7)$$

C being a constant.

Proof: $Ps = \frac{mv^2}{2} + \frac{MV_1^2}{2}$

from which $V^2 = \frac{2\,Ps}{m} \times \frac{n}{n+1}$ may be derived.

The larger n is, or the ratio of gun to projectile, the greater will be the value of the velocity of the projectile, v^2 increasing with the value of M.

Applying the formula (7) to the case of a 0.45 caliber U. S. service carbine, we have:

I. If the arm is rigidly locked in a vise $\frac{n}{n+1} = 1$ nearly, and v^2 is a *maximum*.

II. Let 1300 $f\ s$ be taken as the velocity of projectile, under the conditions as in Case I.

The arm is now free to move, and $n = 120$
$V^2 = C \times 0.992$
$v^2 = (1300)^2 \times 0.992$
$v = 1294$ f. s., a loss of about one-half of one per cent,

a difference so small as not to be appreciable; but if the conditions be exaggerated, and the weights of arm and bullet are made the same, as in the case where a barrel is open at both ends and charged in the center, with equal weights of bullet on either side of the charge, then we have the case of gun and projectile of equal weights, and n becomes unity $\frac{n}{n+1} = \frac{1}{2} =$ 0.5 and $V = 918$ f. s., a loss of 382 f. s. or about 30 per cent. But where the difference of velocity is so small as between the fixed rest and offhand firing (one-half of one per cent) we are driven to find some other theory to sustain the marked difference in the vertical field between these two practices. . . . And now we may add that *recoil* is a term generally employed, as relates to the direct action of a *single* force; but in a more general sense, it is the effect resulting from *several* forces all more or less dependent upon their points of application and the relation of these points to the center of inertia of the system.

It does not affect accuracy of fire in the sense of increasing the *mean deviation* from the center of impact of the system, since flat trajectories with compact clustering of shots result from high velocities and proportionately great recoils, since under similar conditions its effect is constant, and when in the vertical field may be compensated by sight graduation or adjustment.

With the 0.45 caliber service carbine it has been found that the buckling of the barrel, as it is called, is quite marked, and increases proportionally with the powder charge, but the deviation being always in the vertical field is readily compensated. With the U. S. service 0.30 caliber rifle, so-called Krag, the deviation is lateral, to the left, and for short ranges more than compensates the natural drift to the right, due to the rifling. Here the error has been compensated by a curved sight leaf, which for the short ranges has its *drift* correction eliminated, and for long ranges only partially removed. There is an absolute buckling of the early service 0.45 caliber carbine barrel and in direct proportion to the force of the powder charge. Before the bullet leaves the bore, in the twenty-seventh ten-thousandth of a second after it leaves its seat, the barrel in progressing rearward one-quarter of an inch dips (with a 70-grain powder charge) something like the same amount, just as the ball is passing out; whereas when there is a lesser charge, the dip is not so marked. For this reason the anomaly of high-velocity projectiles for *short* ranges striking higher on the target than low-velocity projectiles aimed in the same manner is explained. Of course at the more extended ranges the bullet of high velocity reasserts itself. In view of there being a horizontal deviation to the left in the Krag gun for short ranges, and until the drift tendency causes the bullet to overcome it, and no *buckling* whatever in that arm, it may be well to explain both the cause of *throw* and the cause of buckling.

The carbine barrel was at first not supported on its underside. When fired, and before its inertia was overcome, the first tendency was an upward throw of the gun around its center of inertia. This would seem to tend to throw the projectile upward, as is the case in the short-barrel pistol, but the length of barrel, which is flexible, like a fishing rod (taking an extreme case) resists the sudden upward jerk and bends like a bow, thus dipping slightly at the muzzle and altering the line of direction of the axis as it was placed by the firer in sighting, and this occurs before the ball gets out of the gun.* When the arm is placed in a fixed rest, and the buckling eliminated, the downward tendency in flight is removed, and *this*, and not loss of velocity due to free recoil, causes the bullet to strike lower where there is free recoil than where the arm is restrained.

The Krag rifle is not symmetrical with reference to the vertical plane through its axis when the arm is at the shoulder. The magazine is on one side, and when filled the center of inertia is to the right. The swing or throw of barrel to the left then results from causes above explained, but not being a flexible barrel, it does not hoop or throw to the right, as it would do were these conditions of flexibility as they were in the original service, 0.45 carbine.

We have already extended this discussion so far as to tax the reader, and will add but one word more. The revolver when fired throws upward before the ball passes out, but this is not the principal, or we may say, the real cause of overshooting. The tendency is—a very common one—to sight over the front sight only, and the firer neglects to bring his hammer with rear sight notch into line with the eye, the front sight, and the point aimed at. If he fails to do this he oversights, or holds his weapon in a manner such that to an observer at his side, the arm will be greatly elevated, though the object fired at is near at hand. Those interested in revolver practice may themselves test this theory. Grip the butt firmly, draw slowly and steadily on the trigger, and keep the eye, the rear sight notch, the front sight, and the object always in line while pressing gradually and firmly on the trigger, and keep the arm pointing steadily at the object even after the piece is fired. The improvement in practice will at once be marked if compared with that due to the erroneous method of handling the revolver.

ANODE AND CATHODE SPECTRA.—G. D. Liveing has examined a number of vacuum spectra with a view to determine the differences between the anode and the cathode spectrum, and framing a theory to account for the characteristic differences between them. He finds that hydrogen, nitrogen, and the halogens give two perfectly distinct spectra, but that there is no anode light in oxygen and sulphur. Metallic vapors, such as those of mercury, sodium, cadmium, and thallium, as well as carbonic oxide, show no difference between the cathode and anode spectra, and the two oxides of carbon have an identical spectrum. There are no visible spectra which can be ascribed to the compound molecules of hydrochloric acid or water, while the compound molecules of carbonic oxide and cyanogen give very characteristic spectra. The most convincing argument that the molecules of the gas emitting the cathode glow are unaltered in constitution is that in many cases the spectra are reversible. This could not be unless the molecules which produce the reversed spectra by absorption were the same as those which, under the stimulus from the cathode, emit the same rays bright. The line spectrum of hydrogen is well known to be reversed in the sun, and the reversal of C and F has often been observed in looking at a spark in dense hydrogen. The most striking case of reversal is that of the cyanogen bands. The behavior of the metals suggests that the positive ions consist of molecules of the vapor, which, when de-ionized, vibrate to the same tune as do the like molecules under the influence of cathode rays. In this connection the monatomic character of metallic vapors may have some significance. But in any case the positive ions may very well be molecules of the vapor, and there is no reason why chemically compound molecules, such as those of carbonic oxide, should not become positive ions. In fact, these molecules often play the part of elementary atoms in chemical combination. The author is inclined to the conclusion that the explanation of the solar chromosphere and corona will be found in regarding them as a huge cathode glow.—G. D. Liveing, Proceedings of the Cambridge Philosophical Society, April 22, 1904.

* This accords with Metford's theory.

Correspondence.

A COMPARISON OF LATE DESIGNS OF BATTLESHIPS AND CRUISERS.

To the Editor of the SCIENTIFIC AMERICAN:

Permit me to write a few lines *in re* the battleships and armed cruisers at present being designed, laid down, or under construction, both in Great Britain and the United States. I mention the ships of these two powers alone, as they are and always will be foremost in the art of naval architecture.

In the first place, a good deal is mentioned about the U. S. S. "Connecticut," just launched at Brooklyn and under completion. The launching of the above ship eighteen months after laying down the keel plate is a very creditable performance, and so the completion of the ship in forty-two months seems to be assured. There are comparisons made between the "Connecticut" of the American navy and the "King Edward" of the British navy. Now, taking the five great qualities of a warship into consideration, and the dates of designing, there is not very much to pick and choose from. The "King Edward" class was designed first—in fact two or three of the class are now practically completed—whereas the American ship will not probably be completed for eighteen months or two years. In speed the "King Edward" has an advantage of one-half knot with 1,500 more horse-power, a doubtful advantage I may say, as in the future it seems the line of battle will consist of two classes of ships, viz., the heavy battleship of tremendous power and a fair speed and a lighter class battleship of great speed, hard-hitting power, but less formidable than the heavier ships and less protected, or a class of ship such as the latest designed armored cruisers, of which I shall speak further on, and which are really battleships in disguise. Assuming that the four 12-inch guns of both ships are equal, the next gun to consider is the 9.2-inch on the "King Edward" and the 8-inch on the "Connecticut." Now the 9.2-inch is a far more formidable weapon than the 8-inch. It can be handled as quickly, is as accurate, has far greater hitting and penetrating powers, and is, as it ought to be, weight for weight, a far more formidable gun. Putting the two guns together, the ship which had the more powerful weapon and greater speed would have a decided advantage, even discounting the fact that there would be eight 8-inch against four 9.2-inch. But when it comes to ten 6-inch in the "King Edward" and the twelve 7-inch in the "Connecticut," the case is somewhat changed, and I think there is no doubt that, taking every point into consideration, including the rapidity of fire, the 7-inch gun is certainly superior to the 6-inch. I consider the gun power all round of the "Connecticut" slightly superior to the "King Edward." In the matter of coal endurance, both ships are practically the same; the British ship is slightly superior. In the matter of defensive armor, it is a vexed question; one ship in certain armor has advantages over the other. The belt of the American ship is thicker than the British; the protective deck is also thicker. Above the belt, on the side, it is thicker on the "King Edward," and so on. Each designer has carried out different ideas. In the case of the last quality or qualities (as I will class several in one), viz., designed room for stores of all kinds, quarters of crew, detailed construction of hull, lines of ship, freeboard, etc., British ships always are designed to carry a very large quantity of stores of all kinds, ammunition, etc.—more so in proportion than, I think, in any other navy. They are designed to carry large crews and plenty of room is provided for them. Her freeboard is high, and she probably draws a little more water than the "Connecticut." This would all tend to make her a better gun platform. Lastly, British ships are generally constructed heavier and stronger than in any other nation. So that, looking over everything, and carefully weighing the matter, there is, as a whole, very little advantage, if any, on either side. If there is any, the American ship has it, in being designed later; that is about all.

Then to make a comparison with the "Connecticut" and the "Lord Nelson" class, just designed and being laid down in Great Britain, it shows the advantage in the later designed ship, a description of which is as follows; and to illustrate their extraordinary artillery power, I give a comparison with four of the great naval powers.

	British "Lord Nelson."	Russian "Paul I."	U. S. "Connecticut."	German "O."
Heavy guns	Four 12-inch	Four 12-inch	Four 12-inch	Four 11-inch
Length in calibers	45	40	40	40
Weight of shell.	850 pounds	720 pounds	850 pounds	600 pounds
Penetration in inches of iron at muzzle.	50 to 52 inches	40 inches	47 inches	40 inches

	British "Lord Nelson."	Russian "Paul I."	United States "Connecticut."		German "O."
Auxiliary guns	Ten 9.2 inch	Twelve 8-inch	Eight 8-inch	Twelve 7-inch	Ten 8 2-inch
Length in calibers	50	45	45	50	40
Weight of shell.	380 pounds	188 pounds	250 pounds	165 pounds	310 pounds
Penetration of iron at muzzle	40 inches	27 inches	31 inches	28 inches	30 inches

The "Lord Nelson" class will displace on normal draft 16,500 tons, and at 16,500 I. H. P. natural draft speed 18 knots. Her belt will be 12 inches thick, with 8 inches up the side. The belt is complete, but thinner at the bow and stern, so that in view of the fact that the artillery of the "Lord Nelson" will be of such immense power, there is no ship in any navy that could stand the battering of such a ship, the 9.2-inch gun in this instance being able to penetrate 12 inches of Krupp steel or the best waterline armor of any ship at 3,000 yards, and capable of getting off from three to four aimed shots per minute. Hence, comparing the "Lord Nelson" with the earlier-designed "Connecticut" or "Kansas" class, she is their equal in speed and coal endurance, their superior in defensive armor, and far superior in gun power.

As far as armored cruisers are concerned, the modern armored cruiser nearly approaches a battleship; in point of fact, in many instances they are fast second-class battleships, capable of defeating many of the older first-class battleships. Take, for instance, the U. S. S. "Washington," the British "Black Prince," and the later designed "Shannon" of the "Minotaur" class, a comparison of the three classes of which is as follows:

DIMENSIONS.

	British.		American.
	"Black Prince."	"Shannon."	"Washington."
Length	480 feet	480 feet (about)	502 feet
Beam	73½ feet	73½ feet	72¾ feet
Draft	27 feet	27 feet	25 feet
Displacement	13,500 tons	14,600 tons	14,500 tons
Horse power	23,500	—	25,000 I. H. P.
Speed	22⅓ knots	23 knots	22 knots
Coal supply, normal	1,000 tons	—	900 tons.
Coal supply, full	2,000 tons	—	2,000 tons

ARMOR.

	"Black Prince."	"Shannon."	"Washington."
Waterline belt	6 inch Krupp, 4 to 3 inch at ends	8 inches	6 to 3 inches
Side	6 inches for three-fifths of length	6 inches	5 inches
Deck	—	—	4 to 1½ inches
Bulkhead	About 5 inches	—	5 inches
Gun positions	6 inches	8 inches	9 and 5 inches

ARMAMENT.

"Black Prince."	"Shannon."	"Washington."
Six 9.2 inch, 45 caliber, 27 tons weight 380 pound projectile 10 inches K. S. penetration at 3,000 yards	Four 9.2 inch, 50 caliber, 28 tons weight 380-pound projectile Over 12 inches penetration at 3,000 yards	Four 10 inch, 40 caliber, 33.4 tons weight 500-pound projectile 12 inches K. S. penetration at 3,000 yards
Ten 6 inch, 45 caliber, 7½ tons 100 pound projectile 4¾ inches K. S. penetration at 3,000 yards	Ten 7.5 inch, 50 caliber 200-pound projectile 8 inches K. S. penetration at 3,000 yards	Sixteen 6 inch, 50 caliber 10 -pound projectile 5 inches K. S. penetration at 3,000 yards
Twenty-eight 3 inch and smaller	Twenty-eight 3-inch and smaller.	Thirty-four 3-inch and smaller

These are the classes of ships that in the future will fight along with the heavy battleships, forming a second line. With these may be classed the "Swiftsure" class of battleship recently purchased by the British government from Chili. Dimensions, length 436 feet, beam 71 feet, draft 24¾ feet, horse-power 13,000, speed 20 knots, side armor 7 inches, 3-inch deck, belt 7 inches to 3 inches, 10½ inches on heavy guns, 7 inches on 7.5-inch guns. Armament: Four 10-inch, 45-caliber, 31-ton guns, 500-pound projectile, 12 inches Krupp steel penetration at 3,000 yards; fourteen 7.5-inch, 16-ton guns, 50 calibers, 200-pound projectile, 8-inch penetration at 3,000 yards; eighteen 3-inch and smaller; 900 tons coal normal, 2,200 tons full bunker capacity.

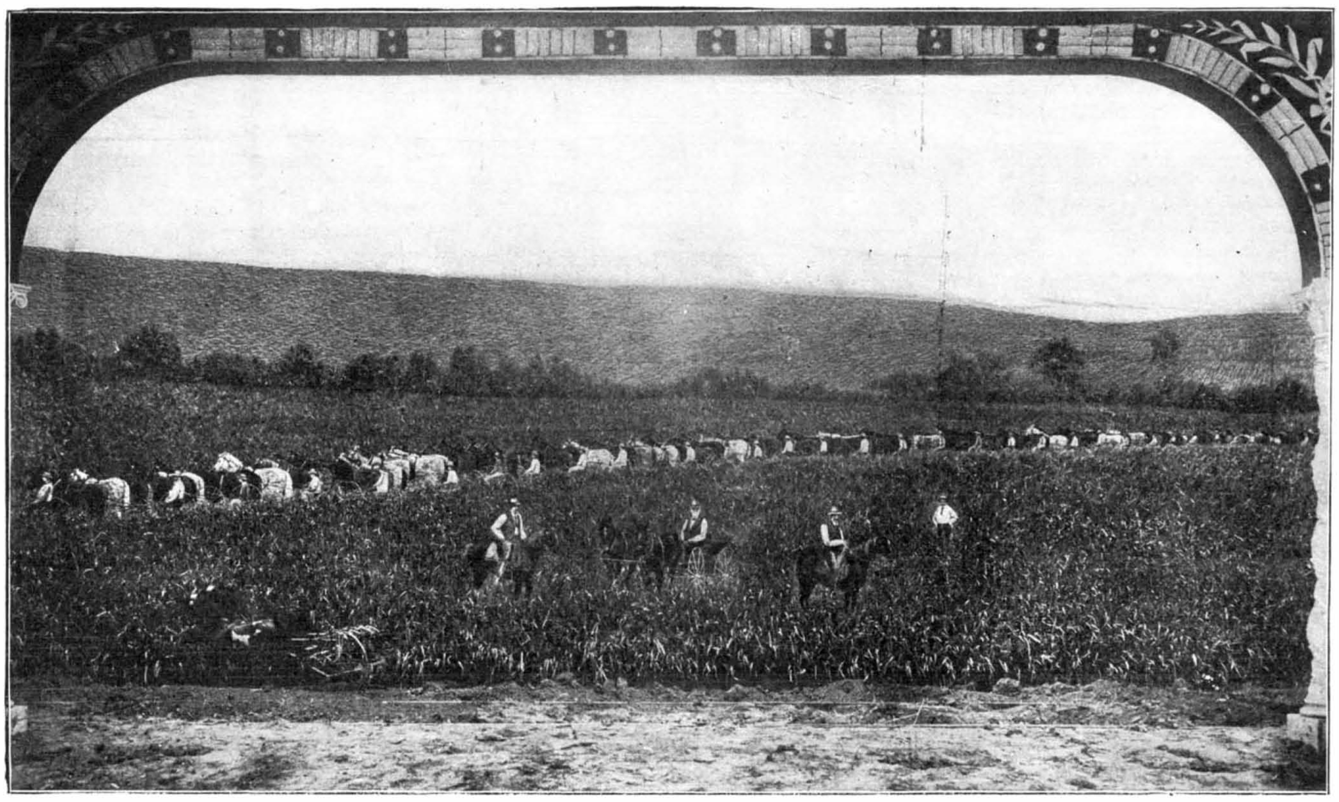
Halifax, Nova Scotia. W. R. SHUTE.

NEW LOW TEMPERATURE PHENOMENA.

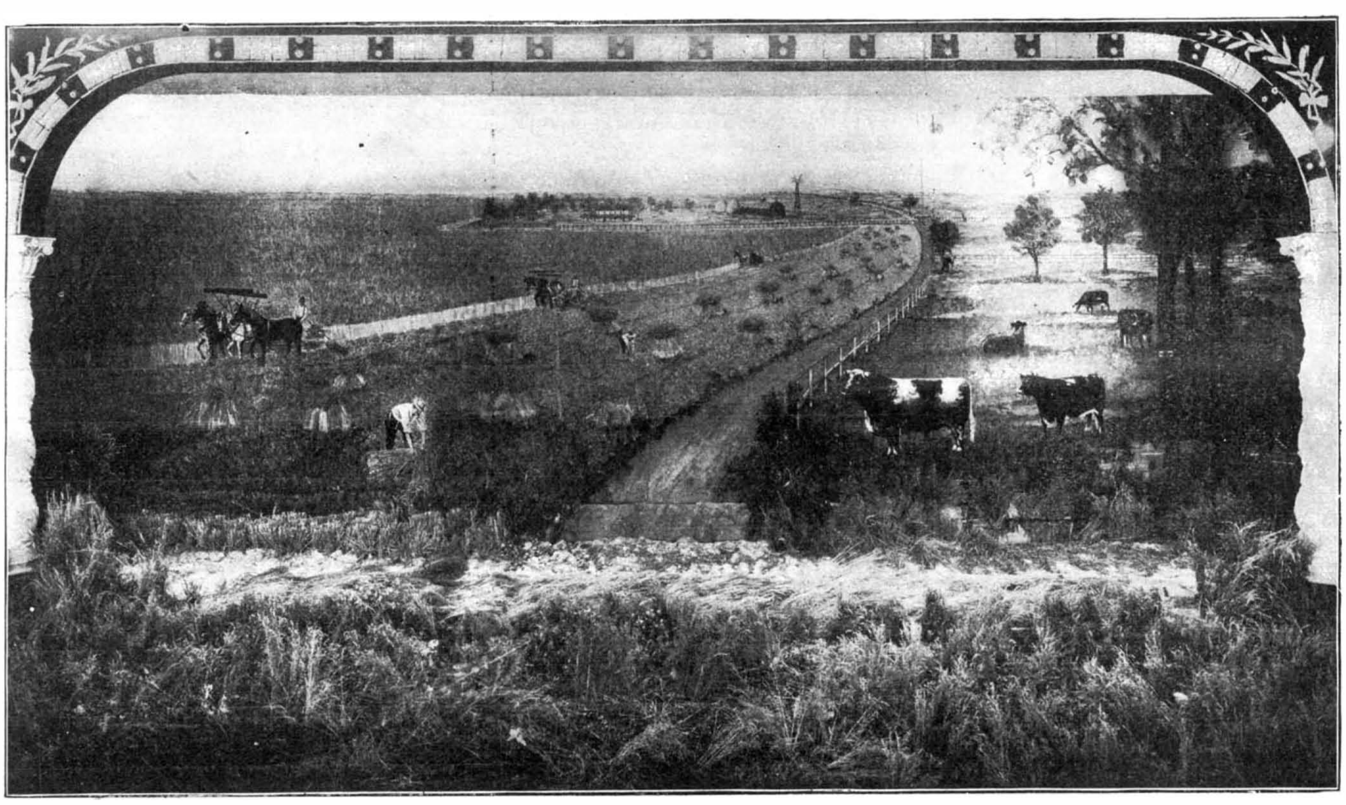
On the last day of the British Association meeting at Cambridge, Sir James Dewar delivered an address on new low temperature phenomena. He said that the matter he was putting before them was not exactly new, as it related to the absorption of gases by charcoal, and many years ago it was found that gases were absorbed by charcoal to a variable extent, and, moreover, that some kinds of charcoal were more active than others, cocoanut charcoal being the most active. Very little, however, had been done in the matter for years. But with the advent of Crookes' radiometer and Sprengel's vacuum pumps the application of charcoal for removing gases from the residual vacuum was tried by him. With the additional use of low temperatures it was easy to remove all traces of condensible gases, such as carbonic anhydride, sulphur dioxide, etc., and with the use of liquid air even the less condensible gases could be removed from an exhausted space, while with liquid hydrogen still greater achievements were rendered possible. Wishing to investigate the character of the most highly exhausted space, it occurred to him that by exhaustion in the usual way, and then employing palladium to absorb the residue, he would get a perfect vacuum, but this did not succeed. He then resorted to the use of cocoanut charcoal. Demonstrating the absorptive properties of this substance, he first showed that some charcoal contained in a tube when immersed in liquid air absorbed air with great avidity; if the supply was cut off an almost perfect mercury vacuum at once ensued, but immediately the supply was again admitted down went the mercury. In another experiment a volume of air was contained in a radiometer in connection with a tube containing charcoal. The radiometer vanes remained absolutely still, but shortly after the charcoal was immersed in liquid air the vanes began to move, and soon attained a great velocity, indicating a very high vacuum. When the liquid air was removed, the radiometer soon slackened, and gradually but rapidly came to rest again, showing that the air resistance had been restored in the radiometer, and that the gas absorbed by charcoal at a low temperature was given off again when the temperature was raised. When a continuous current of air was passed over chilled charcoal the escaping gas was at first all nitrogen, and in a quarter of an hour the gas held by the charcoal contained as much as 60 per cent of oxygen, instead of the usual 21 per cent, and by simply raising the temperature, this 60 per cent air could be collected. All gases were absorbed in larger quantities at —185 deg. Cent. than at 0 deg. Cent. Helium was absorbed in smallest quantity, and then followed hydrogen, nitrogen, argon, carbonic oxide, and oxygen, but with gaseous mixtures the absorption was still greater. The lecturer then showed by a series of beautiful vacuum tube experiments the behavior of nitrogen, oxygen, hydrogen, and argon when submitted in contact with charcoal to the cooling influence of liquid air. The nitrogen tube, for instance, exhibited the usual violet color when the spark passed through it, but as soon as the charcoal was immersed in the liquid air the tube passed through various stages of attenuated brilliancy until ultimately the vacuum became so high that the current could scarcely overcome the resistance. When the liquid air was removed the changes were passed through in the reverse order. Oxygen passed through a similar series of changes, but in the case of hydrogen the absorptive power of the charcoal at the temperature of liquid air was not great enough to render the tube non-conductive. In the case of argon the light due to that element was absorbed, but a brilliancy remained due to a residue of helium which was not absorbed. Nitrogen from the air did exhibit this character because the quantity of helium and neon was one hundred times less than in the argon. It is, therefore, possible by means of this absorption and by the use of different temperatures to separate gases from mixtures and to examine various gases spectroscopically. For instance, in the residue from 200 cubic centimeters of air, neon can be detected by the spectroscope after the nitrogen was absorbed, and helium could be seen in the same way in the residue from three liters of air. By boiling out 300 cubic centimeters of gas from sea-water, rain-water, Cambridge water, and London water, by means of the absorption tubes, helium and neon had been detected in all cases, showing that these elements were more extensively disseminated than was previously supposed. Sir James finally said that hydrogen could be completely absorbed by charcoal at the boiling-point of hydrogen; that helium would require

solid hydrogen, or a temperature of 15 deg. absolute, and that its boiling-point would be 6 deg. absolute, so that Lord Kelvin's predicted 5 deg. absolute might yet be obtained.

Lord Kelvin, in proposing a vote of thanks to Prof. Dewar, said no summary from him of the banquet of scientific exposition that they had enjoyed was necessary, but that each one of the audience would do well to summarize the wonders they had witnessed for themselves. He added that he was filled with expectation as to the condition of things that would be disclosed at a temperature of 5 deg. absolute, where there would be no motion. What would become of electric conductivity, of magnetism, of thermal conductivity? He wished Sir James would continue his electro-conductivity experiments, and bring him copper highly conductive at 8 deg., but as great an insulator at 1 deg. or 2 deg. or 3 deg.—English Mechanic and World of Science.



PICTURE OF A TYPICAL MISSOURI FARM, WORKED ENTIRELY IN WHEAT AND STRAW. AGRICULTURAL BUILDING, ST. LOUIS FAIR.



VIEW IN A 6,000-ACRE MISSOURI CORN FIELD, WORKED ENTIRELY IN VARI-COLORED CORN HUSKS. AGRICULTURAL BUILDING, ST. LOUIS FAIR.

PICTURES IN WHEAT AND CORN AT THE ST. LOUIS FAIR.

By the St. Louis Correspondent of the SCIENTIFIC AMERICAN.

IN point of size of building and extent of exhibits, the Agricultural Palace at the St. Louis Exposition is easily the most important of the great exhibition palaces. With a width of 500 feet it extends for a total length of 1,600 feet, and the aggregate length of the main and cross aisles would represent, if one attempted to look at every exhibit, a journey of several miles. Probably the most elaborate single agricultural exhibit is that of Missouri; which was to be expected, as the Exposition is being held in that State. It is not our intention to attempt to describe in detail the wonderful aggregation of booths, towers, and other structures built up of the native products of the State that makes the display conspicuous, the principal means of decoration of which, it is almost needless to state, is the Missouri corn cob. Undoubtedly the most artistic and meritorious of these displays is a pair of large pictures, each 12 feet in height by 30 feet in length, which have been worked up entirely in products of the farm, and chiefly in corn and wheat. One of these represents a typical Missouri farm scene, and the other is a view of a Missouri corn field. The picture of the corn field was worked up by an artist, from a photograph taken in a 6,000-acre corn field in Atchison County in the northwestern corner of the State. The sloping hill which forms the background and horizon of the picture is worked in by tacking to the boarding upon which the picture is formed innumerable heads of grain. The creek which runs along the base of the hill indicated by a growth of shrubbery and brush, has been admirably reproduced by the judicious use of heads of certain native shrubs, while the near field in which the teams are at work is made of imitation palm foliage, and presents a very lifelike imitation of a field of standing corn. The original photograph was taken when forty-two two-row cultivators were at work, each cultivator being drawn by three horses. The horses are worked in with corn silk and cotton, the shades used being dark and light brown, gray and white. The figures of the men are formed by tacking down pieces of corn shocks of various colors. The farm from which this picture was taken has under cultivation every year from 10,000 to 15,000 acres of corn, this particular field covering about half of the acreage. The whole farm stretches approximately five miles in one direction by eight in the other, and at times as many as 13,000 head of cattle are fed upon it.

The other picture represents a typical Missouri farm and, like that of the corn field, it has been worked up from a photograph. It is made wholly in cereals, the cattle and horses of cotton and corn silk, with enough wool worked in to give the proper shading; as, for instance, in the figure of the bull seen at the right of the picture. The men and the machines, houses, haystacks, etc., are formed of corn husks. The trees are actual sections of trees nailed down to the board. The fence is formed of corn stalks split in half, and the wheat field is formed of actual wheat in the ear, the stubble consisting of short lengths of the proper proportionate size and the standing corn being formed of longer lengths. The nearer pasture, in which the cattle are seen, consists of grass and the far-off pastures are formed of corn husks. The resulting effect in these great pictures is decidedly pleasing, and, at a distance, they could readily be taken for paintings of rather pronounced literalness in form and color.

The reawakening of volcanic activity in recent years induces H. I. Jensen (Roy. Soc. N. S. W.) to examine the records and the possible relations between earthquake and other phenomena, and he confirms Kluge's hypothesis, based upon a study of the period 1850 to 1857, that volcanic eruptions (and also magnetic disturbances) are most noticeable in times of sun-spot minima. In predicting earthquakes we have to consider lines of weakness and of faulting in the earth's crust with regard to the phase, sun-spot minima with regard to the period, the relative position of earth, moon, and sun with regard to the season, and possibly cyclones and atmospheric pressure with regard to the day. Briefly surveying the various hypotheses, the author expresses the opinion that at sun-spot minima less energy is received from the sun, and more heat (and perhaps magnetism) radiated from the cooler earth, particularly owing to the absence of the usual

protective canopy of moisture. The statistics concern the whole world since 1811, and more especially Vesuvius (since 1776), Etna, and the volcanoes of Hawaii.

"WOOL CONDITIONING" IN ENGLAND.

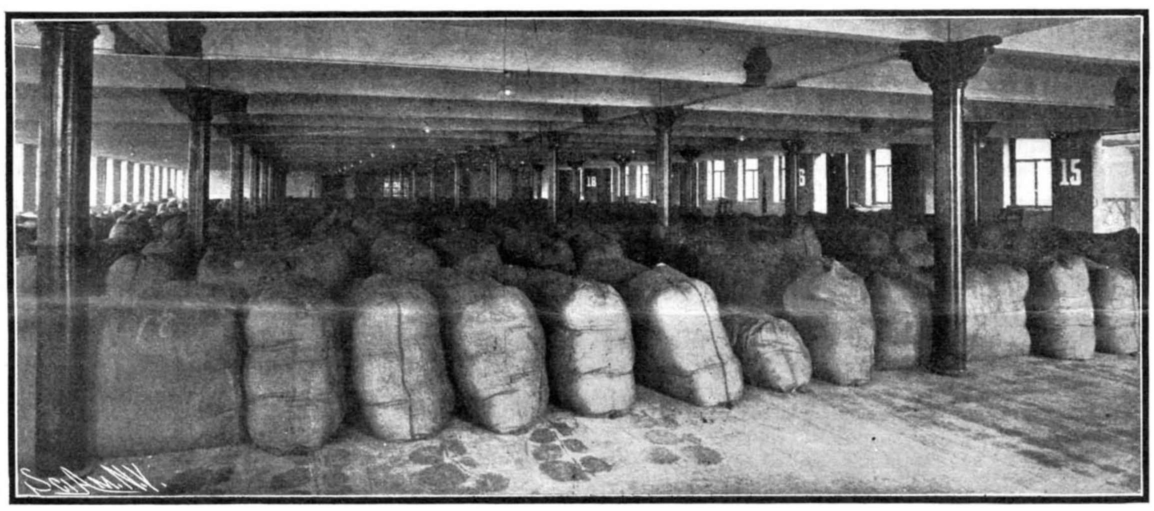
AN IMPORTANT ORGANIZATION FOR THE PREVENTION OF FRAUD.

By the English Correspondent of the SCIENTIFIC AMERICAN.

PROBABLY there are few trades in which deception and fraud can be so efficaciously practised as in the woolen and worsted trade. This fact is especially realized in Yorkshire (England) which is the center of this important British industry. Extensive swindling is practised by unscrupulous dealers, by moistening unduly and otherwise deteriorating the yarn or worsted of which they are desirous to dispose. The consequence is that when the raw material is dried to the proper point, the purchaser ascertains that his bulk is several pounds deficient in weight, so that the individual from whom he made the purchase has obtained an illicit but yet substantial gain in the transaction.

In order to prevent this fraudulent tampering, and to foster fair trading, the city of Bradford, which is the focus of Britain's yarn and worsted industry, has established what is officially designated as a "conditioning house." As the title implies, the function of this organization is to ascertain the condition of the raw material concerned in any transaction, and its stamp of approval or hall-mark is accepted all the world over as a *bona-fide* guarantee that the material under transaction is in every way up to the standard with which it is described. In this manner complete protection is afforded the purchaser, whether he be on the spot to complete his transaction, or conducts it from a foreign land.

This conditioning house is under the control of the municipality of the city of Bradford, and the officers intrusted with the operation of the organization are also appointed by the civic authorities. The staff comprises a superintendent, Mr. W. Townsend, to whose courtesy we are indebted for the particulars contained in this article, and a number of efficient chemical experts and practical operatives. The building was erected at the expense of the citizens at a cost of $200,000. The municipal authorities obtained parliamentary sanction to invest in this enterprise as far back as 1887, but it was not until 1891 that the first conditioning house was organized. It was purely an experiment, because the authorities hesitated to embark upon an extensive scheme, lest it should not receive adequate support to render it financially successful. This scheme, however, met with instant success, and the work of the establishment soon outgrew the capacity of the building, and a new and larger establishment had to be erected. The present institution is the largest of its kind in the world. It is a five-floored building, with a total available floor-space of 15,630 yards, and will store when full about 6,000 bags and bales of raw material.

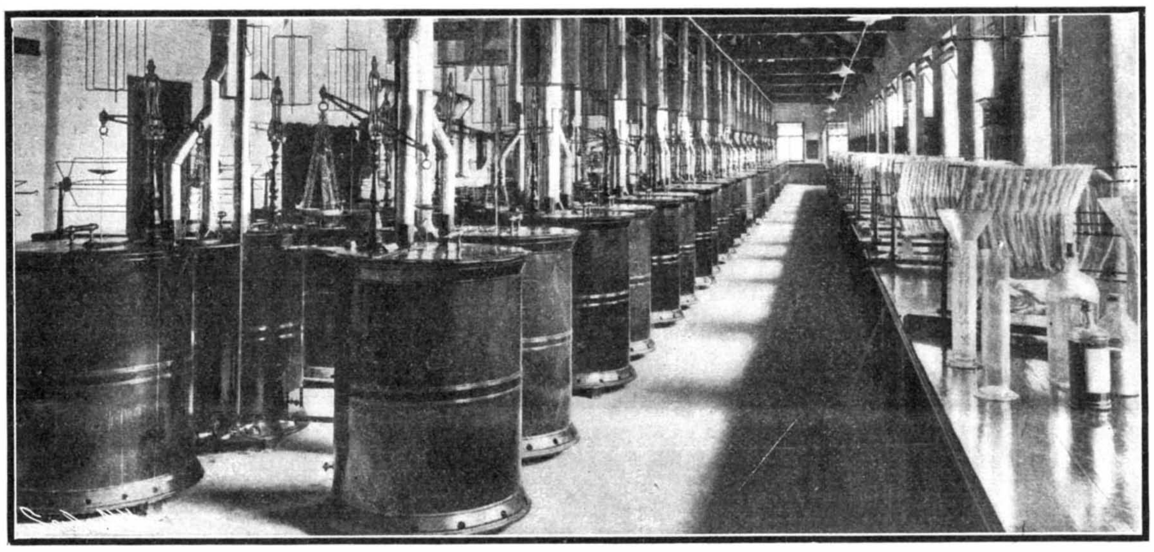


60,000,000 POUNDS OF RAW MATERIAL WAITING TO BE EXAMINED.

The principal functions of this institution may be briefly described as follows: By means of exhaustive tests the net or dry weight of wool, tops, yarns, etc., is ascertained. Furthermore, the quantity of moisture in a submitted bulk, together with the amount of foreign substances with which it is impregnated, are described, as well as the amount of moisture the material is susceptible of naturally absorbing from the atmosphere. The house also certifies the true weight, length, and conditions of articles of trade and commerce, the ascertaining of the net conditioned weights of sample tops, of yarn tops, noils, and so forth, after scouring and cleansing and drying, deciding the true counts, lengths, twists, and strengths of yarns; the measurements of lengths in piece goods; and for testing by quantitative analysis, and other matters referring to dyes and dyeing. From this it will be ascertained that the functions of the house are far-reaching in extent, and exceedingly valuable to those engaged in the woolen industry.

But apart from all deliberate fraud, the material is considerably influenced by natural conditions. For instance, a bag or bale of material, which in June weighs 450 pounds, will be found to be considerably heavier in November. Or again, if stored in a damp place it will absorb the wet like a sponge, so that the value of the bulk will be appreciably augmented, owing to the increase in weight. Furthermore, a pound of wool submitted to a drying operation, and the moisture evaporated by heat, directly it is removed into the normal atmosphere, will reabsorb the moisture.

The conditioning house is divided broadly into two departments. One is devoted to the conduct of tests of samples submitted from various sources, and the other is confined to the weighing in bulk and conditioning of samples taken from the bulk of the material stored upon the premises, for the building serves the purpose of a warehouse until the yarn or wool is required.



WOOL AND TOP TESTING ROOM; 100 OVENS.

The reels upon which the material is wound for insertion in the ovens are shown on the bench to the right.

For the purposes of the tests there are about one hundred ovens. This apparatus is simple both in design and operation. It comprises an upright cylindrical boiler-shaped oven about four feet in height. This oven is really of a double type, comprising an inner and outer casing. The necessary heat applied is gas, the burners being placed beneath and between the walls of the oven. Great attention has to be devoted to the application of this heat. It must be a little in excess of the boiling point of water, but not too great, or the material within the oven will be scorched, and the value and veracity of the results would be falsified.

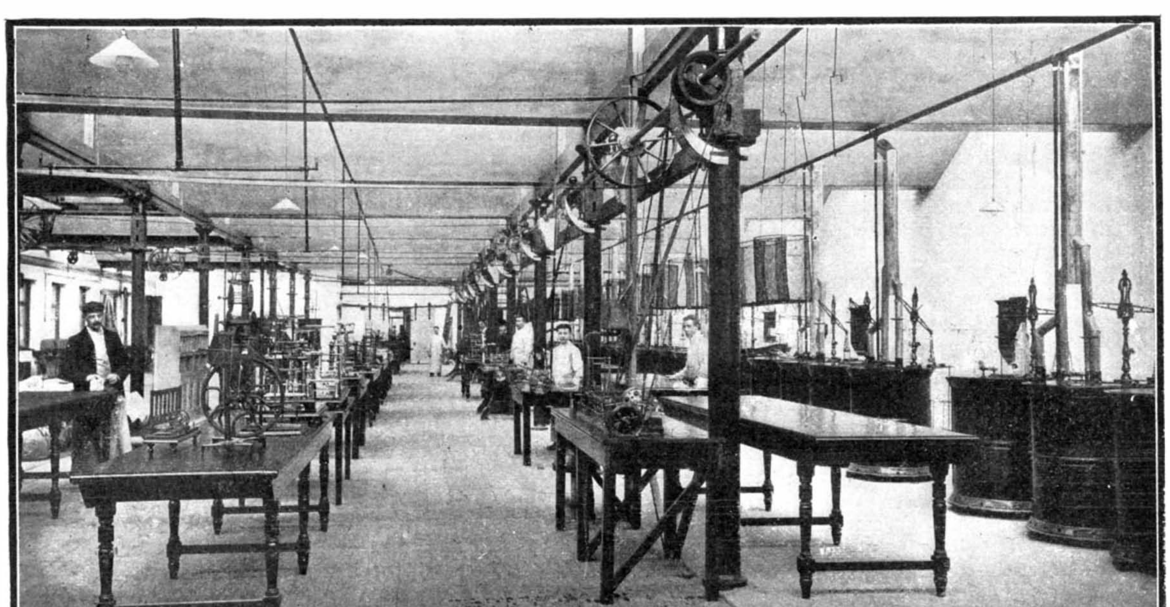
The *modus operandi* of the test is as follows: The raw material is delivered in bales at the conditioning house. Duplicate samples are drawn from the bale or bag. The weight of the sample taken from each bag varies with its nature. This sampling is carried out with the minutest accuracy, but the basis of calculation is roughly as follows: For tops, about 1½ pounds; for wool, noils, and waste, about 2 pounds; yarns in hank, about 2 pounds per 1,000 pounds; yarns or bobbins, 20 to 40 bobbins or about 2 pounds for each 500 pounds. Care is exercised in the drawing of these samples, so as to insure a fair average being obtained of the condition of the bag. Each sample is then divided into three equal lots. Two of these are utilized for independent tests, while the third lot is held in reserve, in case a check test is required, in the event of the difference in the results of the first two lots exceeding one-half per cent.

These samples are weighed by means of delicate scales. The weighing appliances are capable of dealing with any amount, from half an ounce to half a ton, and yet are so sensitive that they are affected by one twenty-four-thousandth part of the gross weight for which the scales are designed. The reels, twist-testers, and other appliances employed in these tests are also specially and finely constructed, so as not to interfere in any way with the operation of the test.

The sample is weighed, and then inserted in the oven. The weight is ascertained immediately preceding its insertion into the oven by means of a weighing appliance attached to the apparatus. For the testing of tops, one pound of the top is wound on a light brass reel, which has also been precisely weighed, and on this reel it is suspended in the oven from one arm of a scale beam, the other arm of which precisely balances the reel. A one-pound weight is then placed in the scale opposite to the suspended top, and the amount lost in the top by the evaporation is ascertained by placing compensating weights in a small scale tray hanging from the same arm as that from which the top depends. The temperature of the oven is raised to 230 deg. Fahr., which is the degree of safe temperature for wool. Cotton cannot be raised to this degree, because in dry air it begins to brown. But on the other hand, silk can stand a higher temperature than wool.

The top is kept in this oven until the arm from which it is suspended does not rise any more, which point denotes that all the moisture absorbent in the material has been evaporated. This process may take any time from ten to fifteen minutes. After the beam refuses to rise any farther, the top is left for a further ten minutes suspended in the oven, which insures the fact that all moisture has been removed therefrom.

During this drying process the operator has care-



MEASURING LENGTHS AND DETERMINING WEIGHTS.

WOOL CONDITIONING IN ENGLAND.

fully followed the movements of the scale beam, thereby observing the actual decrease in the weight of the tops. This, it will be readily observed, is a careful practical calculation, and not a mere theory as to the proportion of the moisture to the material in the one-pound top sample.

The loss of weight in this process as a rule aggregates about one-sixth of the gross weight of the sample, or 10 per cent. Therefore it is a simple arithmetical calculation to determine the amount of moisture in a bag or bale from the proportion existent in the sample extracted therefrom.

All these tests are made in duplicate by different operators, and should the results be widely different, then a third test is undergone as a check. When the conclusions have been derived, the bale or bag from which the sample has been taken is sealed, and a stamped official document indicating the condition of the raw material is forwarded to the seller or purchaser.

The sample, however, directly it is withdrawn from the oven, will commence to reabsorb moisture. Under these circumstances, it would be grossly unfair to calculate the bulk as if it were in an absolutely dry condition, from the simple fact that perfectly dry wool is unknown in the trade. The conditioning house has therefore prepared a standard of allowance, and regain percentage of moisture, as follows:

Tops combed with oil, for moisture, 2 ounces 7½ drachms per pound, or a regain of 18¼ per cent.

Noils for moisture, 1 ounce 15 drachms, or a regain of 14 per cent.

Yarns, worsted, for moisture, 2 ounces 7½ drachms, or a regain of 18¼ per cent.

Yarns, cotton, for moisture, 1 ounce 4½ drachms, or a regain of 8½ per cent.

Yarns, silk, for moisture, 1 ounce 9 drachms, or regain of 11 per cent.

How these allowances are applied may be explained in this manner. For instance, one pound of top combed, with oil, when submitted to the drying operation in the oven, will lose, if in accordance with the standard, 2 ounces 9 drachms in moisture—16 per cent. The resultant weight of dry wool therefore will be 13 ounces 7 drachms, or 84 per cent of the original weight. In a normal atmosphere and under ordinary conditions this 13 ounces 7 drachms will regain 2 ounces 9 drachms of moisture. But the amount of this regain is not 16 per cent of the dry weight of the wool. The calculation works out as follows: $84 \times 19 \div 100 =$ 15.96, which is for all practical purposes 16 per cent of the original weight.

Many of the samples, however, are found to vary from this standard in one or other directions. For instance, supposing nineteen bags of tops combed without oil are submitted for test. The gross weight will aggregate say 8,315 pounds. From this twenty-four samples, each weighing 24 pounds net, are drawn. Sixteen of these samples, each weighing 8 pounds when absolutely dry, will weigh 6 pounds 12 ounces 1 drachm. The bulk of 8,351 pounds, therefore, if all rendered perfectly dry, would weigh only 7,050.23 pounds.

To this bulk, however, is added the authorized 18¼ per cent of moisture, the quantity drawn up for this description of material. The moisture therefore represents 1,286.67 pounds in the bulk. This added to the dry weight will bring the total to 8,337 pounds, which is certified as the correct weight of the tops.

But it will be observed that the conditioned weight is 141 pounds less than its actual weight, due to its containing moisture in excess of the allowance. Sometimes, however, the conditioned weight is greater than the actual gross weight, due to the material containing a less quantity of moisture than specified in the allowance. But in this case the conditioned weight is the one upon which the transaction is based.

The goods which pass through the conditioning house come from all parts of the country, and from the European centers as well. Tests are carried out for private businesses as well as government departments. The tariff for the utilization of the facilities of the institution is based upon a moderate scale, varying from 12 cents to 18 cents per pack of 240 pounds. For yarns in the hank, and for wool and noils, the tariff is 25 cents per test, and for yarns on the tube 50 cents per test. For counts, twist, strength, and length of yarns, the charge varies from 36 cents to 75 cents. The ovens are capable of carrying out 1,000 tests per day, and the average number is about 600 daily, or 180,000 per year. The gross weight of goods passing through the house in the course of a year is approximately 60,000,000 pounds, representing about $20,000,000 in value, from which figures a comprehensive estimate of the scope and importance of the organization may be formed. The income of the institution averages some $40,000 per annum, which is derived from the performance of tests, etc.

So important is the work carried out by this conditioning house, that its official certificate is accepted without question in all parts of the world, as a guarantee. Even in instances of litigation, the evidence of the experts and their adjudication upon the official document is considered as final and conclusive.

WOOD ALCOHOL.

WOOD ALCOHOL, which recently has come to be used extensively in the arts and in the manufacture of culinary and medicinal extracts, is a most dangerous substance when taken internally in sufficient quantity. When pure, it has a rather agreeable, ethereal odor and a sharp, burning taste, and, when ignited, burns with a bluish flame, giving an intense heat. It goes under a variety of names, such as wood spirit, methyl alcohol, burning alcohol, Columbian spirit, naphtha, and wood naphtha. It is used in the manufacture of ether, chloroform, formaldehyde, and methyl chloride, also in the preparation of shellac varnish, since it is a good solvent of resinous substances. As there is no revenue tax on wood alcohol, it can be bought for about 50 cents a gallon, whereas grain alcohol is worth $2.60 a gallon, the tax being $2.17 a gallon. This difference in price is a great temptation for the unscrupulous manufacturer of flavoring and medicinal extracts, and it is frequently found that these contain a large percentage of wood alcohol. Thus it has been shown conclusively by Harlan and by Main that essence of Jamaica ginger, peppermint, and lemon may contain as high as 75 per cent of wood alcohol. The cheaper grades of alcohol also frequently contain wood alcohol.

Wood alcohol is, however, a powerful poison, and there is hardly a month in which one does not read or hear of a case of blindness or death resulting from its use, or from the use of essence of lemon or Jamaica ginger which had been prepared with it. In the last eight years over fifty deaths due to drinking varying quantities of wood alcohol are mentioned in the literature, but this includes only a small percentage of the deaths which have been caused by that substance. Prior to 1896 only one case was reported. This is probably due to the fact that wood alcohol was not used so extensively then as it is now. Ten of these deaths resulted from drinking essence of lemon, eleven from essence of Jamaica ginger, and the remainder from drinking the pure alcohol, mixed with water. In most of these cases the victims had been out on a "spree," or had bought a quantity of cheap alcohol for a celebration at home, and some of them drank as much as a pint of the alcohol, while others drank ten to twelve bottles of essence of lemon or ginger. Death is said to have resulted, however, from less than two ounces. It is important to note in this connection that the action of methyl alcohol differs widely in different individuals. Perhaps the majority of those who drink it escape without permanent damage, while others may die or become totally blind, even if they have taken smaller doses. The exact mode of the production of death is not known, but the researches of Pohl and of Hunt have shown that methyl alcohol is excreted from the body very slowly. The important discovery has also been made that it is only partially oxidized in the body and that its administration leads to the formation of toxic acid (formic acid), and probably also formaldehyde. This is an interesting illustration of the fact that the body may convert one poison into another, which is far more powerful than the one that was ingested. Bongers has made the observation that when methyl alcohol is injected into the rectum of an animal, some of it and also some formic acid is excreted into the stomach. These substances are presumably reabsorbed, either from the stomach or intestine, and some of them again excreted into the stomach, thus forming a "circulation" of methyl alcohol. The result of this "circulation" is that the irritant action of methyl alcohol on the digestive tract is exerted several times. As we shall see below, one of the most marked symptoms of methyl alcohol poisoning is gastro-intestinal irritation, and this is probably due in part to the peculiarity of its secretion.

Another very important sequence of drinking wood alcohol is a sudden development of amblyopia, which frequently results in total blindness. During the last eight years, thirty-six cases of amblyopia following the use of wood alcohol in some form have been reported. Twenty-two of these cases followed a debauch during which wood alcohol was drunk; fourteen were caused by drinking essence of Jamaica ginger or lemon, and eight resulted from the inhalation of wood alcohol fumes while shellacking in a large vat or closed room for several days. The last mentioned cases are interesting, because they show how dangerous this drug is when taken for a period of days, even in very small quantities. This is no doubt due to a cumulative action, because the drug is excreted from the system so very slowly. The experiments of Hunt, de Schweinitz, and Birch-Hirschfeld show that methyl alcohol may be given to an animal in a single large dose and have a less toxic effect than the same dose of ethyl alcohol. If, however, small doses are given daily to two different animals, the one that is receiving the methyl alcohol dies within a week and may become blind several days before death. The retinæ show marked degenerative changes. The one that is receiving ethyl alcohol, on the other hand, shows no bad effects and may even gain in weight. If it is killed and its retinæ examined, no pathologic changes are found.

There is some difference of opinion regarding the pathology of methyl alcohol amblyopia. The experiments of Holden, Birch-Hirschfeld, and Friedenwald have shown that there is a degeneration of the ganglion cells and macular layers of the retinæ caused by nutritional disturbances, due to the vasoconstrictor effect of the methyl alcohol on the retinal vessels. This degeneration is inevitably followed by a degeneration of the nerve fibers of the optic nerve. Other observers are of the opinion that there is primarily an interstitial optic neuritis, but it seems likely that the first view, which is the more recent, is correct. It is probable, however, that a degeneration of the ganglion cells of the retina and an interstitial neuritis are going on simultaneously.

The symptomatology of methyl alcohol poisoning presents a very definite picture, and hence it is not difficult to make a positive diagnosis. There may be first great muscular weakness, with defective heart action, followed by intense gastro-intestinal disturbances with severe nausea and vomiting, intense headache, giddiness, coma and delirium. Some cases die within twenty-four hours, but others recover only to find that they are totally blind. Some do not lose their sight for several days after they have recovered from their intoxication. These cases of blindness may improve under treatment but nearly always relapse and remain in that condition. On examination, there is found a contracted visual field with absolute central scotomata. The pupils are widely dilated and irresponsive to light. Ophthalmoscopically there is noted a blurring of the edges of the optic disks, positive optic neuritis, and later complete optic atrophy.

The treatment of methyl alcohol amblyopia is unsatisfactory. Some cases have improved under free catharsis from jalap, calomel, and salines, combined with diaphoresis from hypodermics of pilocarpin. This treatment, however, must be given during the first few days of the acute inflammatory stage if any beneficial results are to be expected. When atrophy begins to show itself, strychnine is given hypodermically in increasing doses until the point of tolerance is reached. Potassium iodide has also been used, but it must be remembered that the prognosis is very bad when signs of atrophy begin to appear. In most cases affection goes on until complete blindness results, regardless of what treatment is given.—Jour. Am. Med. Association.

THE RELATIONS OF TECHNICAL CHEMISTRY TO THE OTHER SCIENCES.—I.*

By CHARLES E. MUNROE, Ph.D., Head Professor of Chemistry, George Washington University; Expert Special Agent of the United States Census Bureau in charge of the Chemical Industries.

As the term technical chemistry is usually used, it refers to the commercial production of substances through a change in the chemical composition of the matter employed in their manufacture. All manufacturing operations are either chemical or physical ones or both chemical and physical. The manufacture is a chemical one when the substance or substances acted upon undergo a change in composition. The manufacture is a physical one when the substance acted upon undergoes a change in form, state, state of aggregation, appearance or properties without any change in its composition. Many manufactures, probably the majority, employ both chemical and physical processes in their operations. In most manufactures the chemical processes are the basic ones producing the material which is afterward shaped and assembled by physical means in the form in which it is to be used.

The variety of substances embraced in chemical technology is shown in such a work as Wagner's, but no statistics indicating its magnitude are to be found except in the reports of the United States Census, this being the only country which takes a census of manufactures. Following the classification of Wagner, I have compiled these statistics for the years 1890 and 1900.

STATISTICS OF CHEMICAL MANUFACTURES IN THE UNITED STATES, 1890 AND 1900.

Year.	Number of establishments.	Number of wage-earners.	Total wages.	Cost of materials used.	Value of products.
1900	84,172	1,038,543	$469,848,022	$3,392,211,974	$4,962,715,787
1890	58,195	710,485	311,369,495	2,177,443,777	3,165,768,188

The term technical chemistry may, however, properly be extended to include the work done by chemists not engaged in manufacturing but which aims at a utilitarian application of the results. First in order of development among these is the class of chemists engaged in the work of chemically inspecting material from all sources to ascertain its suitability for its proposed uses, or its purity, or its conformity with the specifications under which it was purchased. All economically managed and well-conducted operations of any magnitude to-day are subjected to this check. In fact, we may say that, since governments by legislation specify the fineness as well as the weights of the gold and silver coins they issue, and since the fineness of these coins as well as of the bullion in the treasury is constantly proved by analyses, therefore every commercial transaction throughout the civilized world is eventually based upon the results of chemical tests. The historian Du Cange gives the credit for "inventing" assaying to Roger, Bishop of Salisbury, during the reign of Henry I. Be this as it may, it is owing to the accurate analyses of assayers such as Tillet, Stas, Graham, Torrey, Eckfeldt, Roberts-Austen, and their successors that the credit of our metallic currency has been and is maintained. The office of public analyst and assayer or, as it is often styled, state assayer is of long standing, Charles XI. of Sweden having, in 1686,† established a technical laboratory for the chemical examination of natural products and the working out of processes for their practical utilization. The census of 1900 reports that there were 8,847 persons practising in the United States in that year as chemists, assayers, and metallurgists and it is gratifying to observe that this class of technical analytical chemists is rapidly increasing in numbers and importance.

Second in the order of development is the work done

* Address prepared for and read at the International Congress of Arts and Science, St. Louis, September 23, 1904.

† History of Chemistry, E. von Meyer, p. 138.

in the technical research laboratories where methods are tested and criticised, processes are developed, apparatus and machinery invented, new products discovered, new applications for known products found, and where yields and costs are ascertained. Notable among these are the famous research laboratories of the Badische Anilin und Soda Fabrik, the Wellcome Research Laboratories, and many others that may be readily called to mind, and so fruitful and valuable have these establishments proven that similar ones are rapidly being established about manufacturing works. Their success seems also to have suggested the formation of the independent research companies formed explicitly to combine research with practical application, especially in electro-chemistry, one such located in this country having, among others, developed processes for the manufacture of barium hydroxide, synthetic camphor, and nitric acid from atmospheric nitrogen.

Of necessity many of the arts preceded the sciences, and this was especially the case in chemistry, as many of the arts embraced in technical chemistry, such as the utilization of fuel as a source of energy, the manufacture of alcoholic beverages, bread, soap, glass, and dyestuffs, the isolation of metals, the expression of oils, and the extraction of sugar, starch, gums, glucosides, and alkaloids among others were practised, in an empirical way, long before the science of chemistry took form. In 1724, after chemistry had emerged from alchemy, Boerhave defined chemistry as "an art which teaches the manner of performing certain physical operations whereby bodies cognizable to the senses or capable of being rendered cognizable or contained in vessels are so changed by means of proper instruments as to produce certain determinate effects, and at the same time discover the causes thereof for service in the arts."

The science of chemistry was a growth from the art and gradually developed. It was a crude science when the phlogiston theory was propounded and many of the advocates of this theory, such as Stahl, Marggraf, Scheele, Bergmann, Priestly, Cavendish, and Black, contributed much valuable experimental and observational data from their researches. But it takes date as a recognized science when Lavoisier provided it with a systematic notation and nomenclature, Dalton enunciated his atomic theory and Berzelius demonstrated the constancy of combining proportions and of constitution, and its growth since the beginning of the nineteenth century has been almost marvelous.

The distinction between pure and applied chemistry was universally recognized toward the middle of the eighteenth century; special textbooks on technical chemistry, in which theory was combined with practice, and embracing analytical processes, particularly as they related to ores, being issued. In fact from the outset, technical chemistry has naturally drawn continually upon pure chemistry for products, processes, and apparatus, modifying the processes and apparatus to meet the conditions of factory practice. So rapid, however, has this adoption of the appliances of the university laboratory by the technical chemists become in these recent years, since university-bred chemists have been received in continually increasing numbers in technical chemistry, that it has proved a source of embarrassment to teachers of chemistry in this country and for the following reason:

From the founding of the United States it has been a settled policy of the government to foster education, and therefore the First Congress, in legislating on the tariff, exempted philosophical apparatus and instruments imported for use in education from duty, and this legislation was re-enacted with enlarged provisions in every tariff act passed by Congress, except during the civil war, and once in 1846, when it was apparently omitted by inadvertence. This provision seemed to serve all intended purposes until some thirty years ago, partly because there were but few active laboratories for the teaching of chemistry with a small number of students, and that the supplies were imported for only a part of these laboratories. However, with the increase in research laboratories in universities and technical schools, the introduction of laboratory courses for the large classes of pupils in the secondary schools, and especially the appointment of a considerable number of teachers of chemistry who had been educated abroad, the demand for foreign-made apparatus and supplies became quite considerable, and as the importations grew in magnitude and frequency differences arose between the customs officials and the importers as to whether the goods imported were actually those designated in the act, the customs officials, as was natural, considering their functions, ruling for that interpretation of the laws which would yield the government the greatest revenue. Controversy, which became quite heated, arose particularly as to the meaning of the terms "philosophical and scientific apparatus, instruments and preparations," and in 1884 the Secretary of the Treasury, to avoid any appearance of arbitrarily overruling his subordinates, which would have been subversive of discipline, took counsel of the National Academy of Sciences, but its opinion as rendered, while perfectly correct, failed of effect, and the controversies got into the courts on issues between merchants and the customs service, in such form as to lead to decisions which the customs officials regarded as supporting their controversies against the schools. Such were the conditions in 1893, when the American Chemical Society appointed a committee on duty-free importations, which made an exhaustive search into the legislation, an inquiry into the litigation, and a study of the entire situation until, finding a favorable opportunity in an issue brought before the proper tribunal, it convinced the judges that there were no instruments, apparatus or preparations which to-day were exclusively used in teaching or research—that, on the contrary, our manufacturers and practitioners are so keen to utilize every resource at command that they are the first, usually, to test, and if found profitable, to adopt any new invention in apparatus or discovery in preparation, while teachers must usually await the voting of appropriations or gifts from benefactors before they can possess them; and that, as no distinction can be drawn either arbitrarily or from the rule of "principal use," we must revert to the "evident intent" of Congress to exempt education from the burden of the tariff and in each instance the levying of duties or admission of the goods free must be determined solely by the fact as to whether or not they are to be used in the institutions designated by the act for educational purposes and research. It is pleasant to record that the Board of Appraisers, after thoroughly reviewing the history, adopted this view, and that during the present year Assistant Secretary Armstrong, in charge of the customs service, has promulgated it in a very satisfactory form for the instruction of his subordinates.

This is but one instance of a multitude which may be cited showing how technical chemistry "treads on the heels" of pure chemistry. It depends especially on the votaries of the latter for accurate determinations of chemical constants. Prof. P. W. Clarke has emphasized the importance of this in the case of atomic weights, taking the case of chromium* as an example. He says: "The older and less accurate determinations for chromium led to the figure 52.5. The more recent and more accurate have given 52.1 as the number. The European technical analysts who analyze chromium ores for the sellers use the first mentioned number; the chemists for the consumers in this country use the latter number, with the result that the difference in value on a cargo of ore weighing 3,500 tons is $367.50."

The technical chemist has been keen to appreciate the necessity for authoritative standards by which his work might be controlled and to which matters in controversy might be referred. He has especially welcomed and willingly assisted in the formation of standards bureaus. In fact, the movement for the creation of a National Bureau of Standards in the United States originated in the Association of Official Agricultural Chemists through Mr. Ewell, and though when, on the motion of this gentleman, the plan was afterward indorsed by the American Chemical Society, it received the complete approval of the pure chemists, Dr. William McMurtrie and Dr. Charles B. Dudley, who stand in the front rank as technical chemists, were most active in its promotion and successful in convincing our national legislators of the economic advantages which would result from the establishment of such an institution invested by law with the proper authority.

Technical chemistry is indebted to pure chemistry for much precise information regarding the properties of substances, especially as to their behavior toward reagents, and for accurate and carefully investigated analytical methods like those with which the honored name of Wolcott Gibbs is associated. But the technical chemist revises these methods and adapts them to his special needs, as shown in the standard work of Blair's on the Chemical Analysis of Iron, and in others that might be cited, while he verifies the published data as to the particular substances with which he has to deal. Realizing that "time is money," he has devised, with the aid of the collected information, rapid methods of analysis† which enable one to arrive at an approximately true and in some instances a very precise result in a few moments when the academic methods require hours and perhaps days to arrive at the same conclusion. It is true that methods of this nature devised to meet technical needs have been generalized and made more available in the university laboratory. As an early example of this we have volumetric analysis, devised by Descroizille and Vaquelin, investigated and generalized by Gay Lussac, and as a recent example we have the use of a rotating electrode in electrolysis, long employed in the arts, critically studied and generalized by Smith, by Gooch, and by their pupils. Yet the systematic treatment of the accumulated material, the working out of a comprehensive scheme of qualitative analysis, and the collating, the sifting, and the arrangement of correlated methods for quantitative determinations in a connected manner are due to C. Remigius Fresenius, who for so long conducted a technical analytical laboratory at Wiesbaden, and his publications are classics.

But technical chemistry has especially looked to the pure chemist, with leisure for thought and work with libraries and other facilities at command, to correlate and discuss data, suggest hypotheses, invent theories and discover laws which the technical chemist has been ready to test and, when proved, to be guided by. To-day we find the technical chemists earnestly studying Arrhenius's theory of electrolytic dissociation, Willard Gibbs's phase rule, Van't Hoff's law governing osmotic pressure, Guldberg and Waage's law of mass action, and the many other valuable generalizations which have resulted from the systematic cultivation of the borderland between the sciences of physics and chemistry that has been going on with increasing activity during the past quarter of a century. It is safe to say that the series of text books of physical chemistry now being edited by Sir William Ramsay, and of which the "Phase Rule and Its Application," by Alex. Findlay, is the pioneer, will find their way largely into the libraries of the technical chemists. Many examples may be cited of the utilization of these generalizations in the solution of problems in technical chemistry, but Christy's* admirable researches into the *rationale* of the cyanide processes for the recovery of gold from its ores will suffice. The experience of the past has repeatedly demonstrated the commercial possibilities that are latent in scientific theories. A famous example is found in the commercial development of benzene. Lachman, in 1898, after referring to its discovery by Faraday in 1825 and its production from benzoic acid by Mitscherlich nine years later, says:† "These famous chemists little thought that their limpid oil would once lay claim to be the most important substance in organic chemistry; that it would give birth to untold thousands of compounds; that it would revolutionize science and technology. The technical development of benzene and its derivatives employs over fifteen thousand workmen in Germany alone; the commercial value of the products reaches tens of millions of dollars; by far the greater portion of the research work done to-day is concerned with the same group of substances. Nearly all of this tremendous activity is due to a single idea, advanced in a masterly treatise by August Kekule in the year 1865. Twenty-five years sufficed for the chemists of all nations to recognize the inestimable importance of the benzene theory, for in 1890 they came together at Berlin to do honor to the man who had created a new epoch in the science." There is abundant verification of Hoffmann's statement that "the technologist is not likely to leave long without utilization any fact of science which may be developed and made valuable from the technical side," and of Ostwald's saying "that the science of to-day is the practice of to-morrow."

In his most attractive book, "Physical Chemistry in the Service of the Sciences," Van't Hoff says: "There exists in Germany a very beneficial co-operation between laboratory work and technical work. Both go as far as possible hand in hand. After physical chemistry had made several important advances and was firmly established in such a way that pure chemistry was assisted by co-operation with it, Ostwald judged correctly that this co-operation would also be valuable in technical directions," and these views led to the founding of what is now the German Bunsen Society for Applied Physical Chemistry, whose considerable membership comprises both men of pure science and representatives of technical science. The suggestions of applications from men such as Ostwald, Van't Hoff, Bancroft, and others, accompanied as they are by striking demonstrations, are always most welcome and appreciated. But it is no new custom for the most eminent exponents of pure science to step for a while into the field of application. We have but to cite the names of Baeyer, Berzelius, Bunsen, Davy, Debus, Dumas, Faraday, Fischer, Frankland, Hoffmann, Liebig, Mabery, Remsen (to whom the medal of the Society of Chemical Industry has just been awarded), Williamson and Wurtz as examples. Or taking a single technical subject, such as the explosives industry, we have Lavoisier perfecting the manufacture of gunpowder; Gay Lussac serving on the Advisory Committee of Powders and Saltpeter; Berthollet inventing chlorate powders; Liebig investigating the fulminates and devising means by which the commercial manufacture and use of mercuric fulminate was made possible; Schoenbein discovering gun cotton and introducing it for use as a propellent; Bunsen, with Schischkoff, making researches on the composition of powder gases and powder residues; Berthelot, led by a patriotic desire to serve his country in time of peril, exhaustively experimenting with explosives of every description, collecting and correlating the data of his own experiments with those previously recorded, and combining this with the descriptions of the attendant phenomena and the theories he had deduced from analyses of all this material in his "Force of Explosive Substances;" and Mendelejeff and Dewar developing the smokeless powders adopted by the countries of which they respectively are citizens.

While technical chemistry is under manifold obligations to pure chemistry the indebtedness does not stand unrequited. I would amplify this branch of my subject but that it has been so admirably done by Dr. William McMurtrie in his address on "The Relations of the Industries to the Advancement of Chemical Science"‡ in which it is shown that many discoveries which have materially affected pure chemistry have been made in the factories. It is a well-known fact, and quite in the nature of things, that the pure chemist is dependent upon the technical chemist for most of the material used in his researches, and the publications contain frequent acknowledgments of this fact.

(To be continued.)

N-RAY OBSERVATION OF THE SPINAL MARROW.—A. Broca and A. Zimmern quote some first results of their investigation of the spinal marrow by means of the N-rays. They succeeded in identifying certain nerve centers by this means with greater exactness in the living subject than had been possible by any other method. Points of maximum emission of N-rays were found at the second dorsal vertebra, the fifth and eleventh dorsal vertebræ, the second lumbar vertebra and the middle of the sacrum. These points were found to be the same in men, women, dogs, and

* J. Am. Chem. Soc., 19, 350; 1897.

† The number of determinations made in one week in the laboratory of the Bethlehem Iron Co. amounted to 2,444: accurate analyses of carbon being made in 12 minutes, of manganese in 10 minutes, and of phosphorus and silicon in 30 minutes. Eng. and Min. J. 60, 375. 1895.

* Trans. Am. Inst. Mining Eng. 26, 735; 1897: and 30, 864; 1901.

† Spirit of Organic Chemistry, p. 21.

‡ Proc. A. A. A. S. 44. 65-85; 1896.

guinea-pigs. The second dorsal center probably corresponds to the cilio-spinal center of physiology. The second lumbar is the genito-spinal and vesico-spinal center, as the authors were able to verify by the examination of some abnormal cases.—Broca and Zimmern, Comptes Rendus, May 16, 1904.

A NEW FLOORING MATERIAL.

ARCHITECT SIEGWART, of Lucerne, has patented a new system of a concrete flooring, consisting of hollow tubes of mortar and iron. It is fireproof, and will, I believe, be of considerable interest to builders in the United States.

It is claimed that this system is an improvement on the inventions of Monnier, Hennebique, Koener, and others. It consists in manufacturing, in a factory, the mortar into hollow beams for forming a floor or roof ready for delivery to the builder—one which can be laid together on the supporting walls without planking. By this means one floor after another can be laid in a very short time, and the floor so laid can be used to work upon at once without scaffolding.

This appears to me as a great advantage compared to the usual devices of stone, plaster, etc., which are dependent largely upon temperature and weather, and in all cases must be left for some days to dry before they can be walked upon.

One advantage claimed for the Siegwart system is that no workmen are required other than the ordinary laborers. Another fact which should be considered is that armored beams which are made in the building can only be depended upon for uniformity when the mortar is mixed in exactly the same proportions and when it is not influenced by shocks, frost, or rain during the time of setting. When this work is done in the factory it is far easier to secure uniformity and protect the beams against weather conditions.

The beams manufactured at Lucerne have a uniform breadth of 25 centimeters (9.84 inches) and are manufactured in five sizes, viz., 9, 12, 15, 18, and 21 centimeters (3.5, 4.7, 5.9, 7.08, and 8.36 inches) high, according to the length of span and load. The size of the iron rods in the beams is between 5 and 10 millimeters (0.196 and 0.39 inch), and generally six rods are used in each beam. Two of these rods are laid parallel with the under border of the beam, and the other four are bent upward into the form of a knot at the ends in order to strengthen their holding power. The proportion of cement with coarse sand is 1 to 4. Though the beams are made hollow, they have the same supporting power as though they were solid, with a great reduction of weight. This is an important factor where freight charges are to be considered. The beams, being hollow, offer also more favorable conditions for heating. The sides are ridged, so that the cement for joining them together can enter into the vacant spaces and thus form a solid mass. The laying together of the beams is done exactly as with wooden beams.

The beams are supplied in different lengths. In Lucerne they are made to 5.5 meters (18 feet) long; in Italy and Germany, up to 6.5 meters (21.3 feet) long; and in Russia, up to 7.5 meters (24.6 feet) long. They can be used, in addition to floors, for terraces, roofs, staircase supports, and for walls where there is a side pressure, as, for instance, in coal bunkers, warehouses, etc. It has been demonstrated that with a load from four to five times as great as the normal the beams have only bent to the extent of 1 or 2 millimeters (0.0394 and 0.0788 inch).

The chief advantages claimed for these beams are: Great supporting power and security from fire; they come dry and hard from the factory and can, therefore, be used at once as floors for working on; greater facility and speed in building is secured by their use; freedom from excess of heat and cold by reason of their being hollow; thickness of completed floors is reduced by their use; the beams can be used as a heating floor by sending warm air through them.

The manufacture of the beams as practised in the Siegwart Beam Factory in Lucerne, Switzerland, and in other European countries is very simple. They are manufactured in layers of 2.5 meters (8 feet) breadth and not singly. The hollow spaces are formed by means of iron molds, around which the cement is laid and the iron rods placed in position. These iron molds are constructed so that they can be reduced in size by the turning of a screw and withdrawn when the cement has become hard. The beams are cut, before the cement has set, by means of a patent cutting machine, and which can be placed in any position.

Six to eight hours after laying the beams the iron molds can be withdrawn, but they are generally left to harden for four to six days before they are separated. After two to three weeks they are ready for delivery.

There are already a large number of buildings, both public and private, in Switzerland in which the Siegwart beams have been employed, and in all the buildings now in course of construction in Lucerne they are being used.

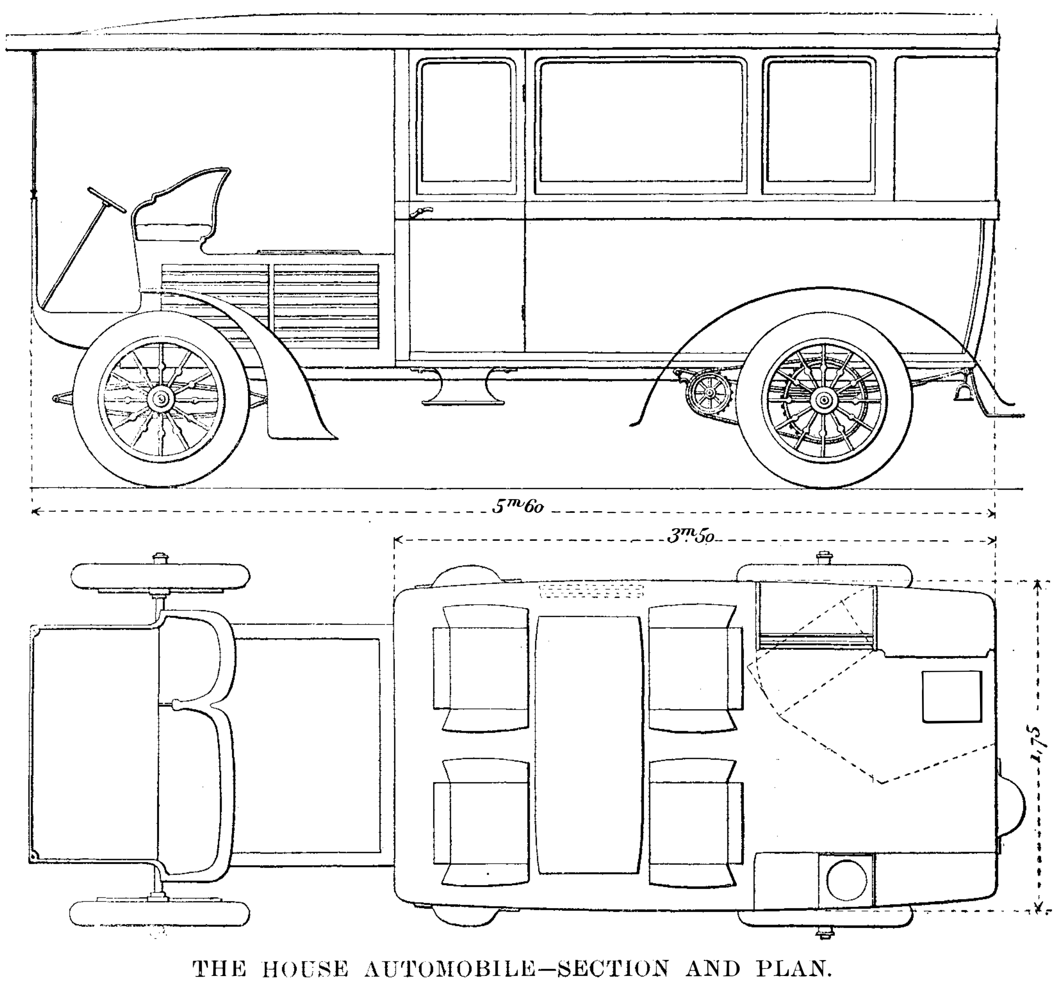
At present there are three factories in Germany, three in Russia, and one in Italy occupied in manufacturing beams under the Siegwart patent.—Henry M. Morgan, Consul at Lucerne, Switzerland.

A HOUSE AUTOMOBILE.

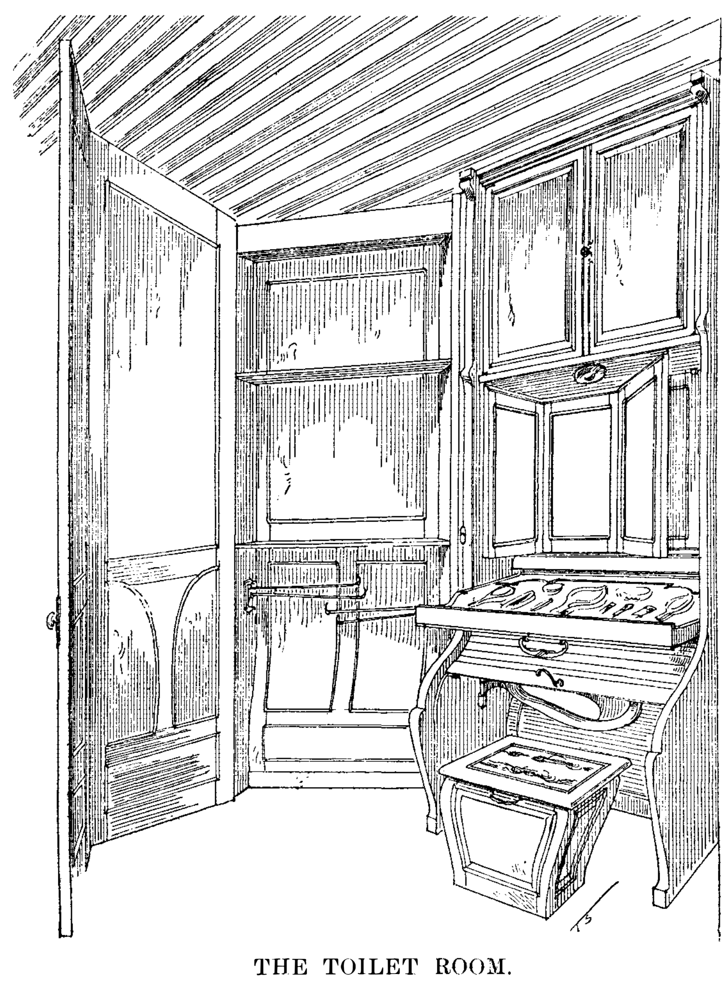
THE traveling house that we are about to describe is not the first one that has been constructed, although we have not as yet met with a genuine house carriage in the highways propelled by steam or gasoline. The house under consideration possesses no mechanical or motor parts, for the simple reason that the only part that is at present constructed is the body, which may be mounted upon any strong chassis that the owner may choose to select for it. It is exhibited by M. Tony Selmersheim in the section of architecture of the salon of the Société Nationale des Beaux Arts, where the visitor who examines it cannot fail to be struck by its ingenious arrangement. The space utilized represents a surface of 11.3 x 5.25 feet, but, were we not acquainted with the actual figures, we might be led to think that the area was still greater, so much room is there left to move about in outside of the numerous pieces of furniture.

THE DINING ROOM.

The accompanying illustrations will show the reader how easy it is for a person of taste to give an artistic form to a conception that we might think ought naturally to have remained in the industrial domain. The briefest description that we can give of it is the following: In the front part of the carriage is a space measuring 6.5 feet in length and 5.25 in width, in which are four arm chairs mounted upon slides, which makes them convertible into couches provided with bedding, besides a table mounted upon a forged iron frame, the very ingenious design of which permits of folding it up so compactly that it is but 4 inches thick. Thus we have a parlor, a dining room, and a bedroom. In the hind part is a small box for shoes, lockers for a lady's and gentleman's clothing, four drawers for silverplate

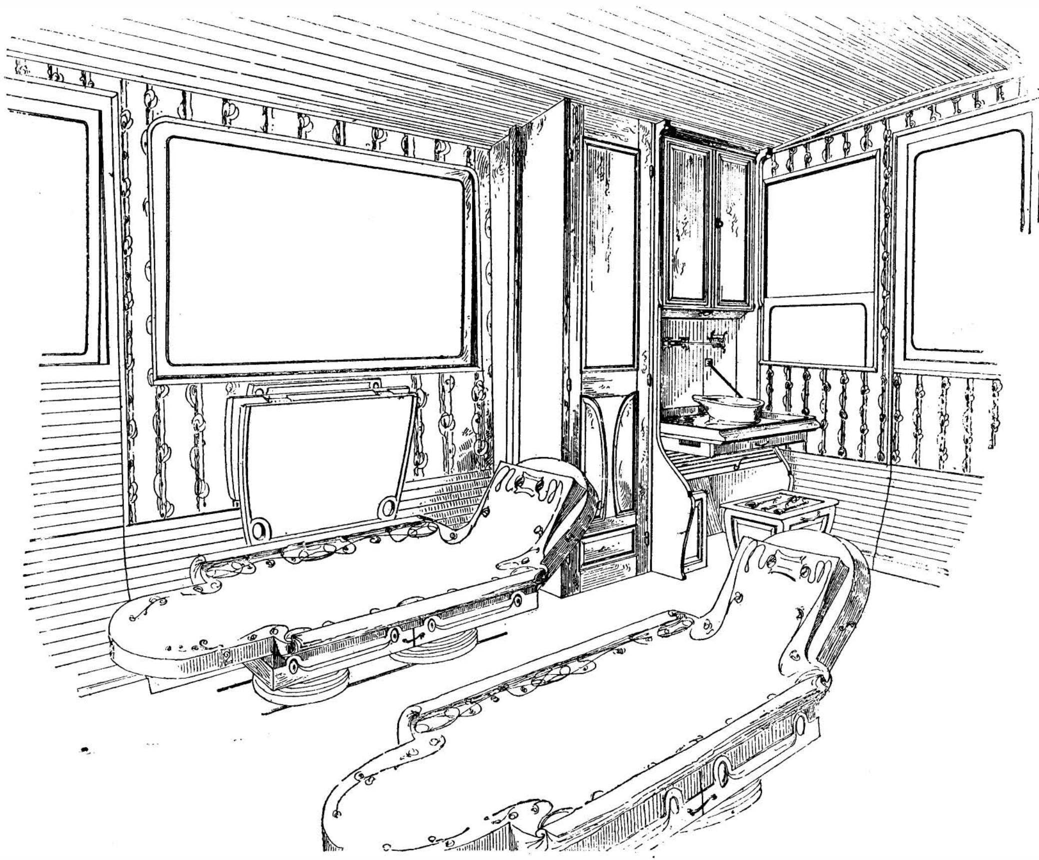


THE HOUSE AUTOMOBILE—SECTION AND PLAN.



THE TOILET ROOM.

and other objects, and a small kitchen with special ventilation closed by swinging doors. The lining of this kitchen is of opaline, and an opaline shelf continuing above the lady's locker serves for holding dessert. A closet, with a solid door, for provisions, completes this compartment. Opposite, the visitor will find a piece of furniture consisting of a combined toilet-table with



THE BEDROOM.

three hinged mirrors, a swinging wash stand with mirror at the back, hot and cold water faucets, a linen-closet with beveled glass doors, and, for ordinary use, a pivoting nickel basin with hot and cold water faucets. Finally, a box on slides serves as a urinal. This part of the carriage is isolated from the front part by folding doors.

The joiner-work and hangings of the interior of the carriage are of the most artistic character.

Two lamps suspended from the ceiling light the parlor, a lamp suspended by a flexible wire lights the kitchen, and a lamp with a metallic reflector illuminates the toilet room.—Translated and condensed from L'Automobile for the SCIENTIFIC AMERICAN SUPPLEMENT.

COAL CONSUMPTION OF LOCOMOTIVES.

ONE of the reports at the convention of the Master Mechanics' Association last June, received too late for appropriate discussion, was that on locomotive coal consumption. It was one of the most valuable documents presented, and should have earnest attention, because locomotives are larger than they used to be. The conclusions of the committee, of which Mr. H. T. Herr was chairman, are presented here, and it is hoped that they will be carefully studied, particularly with reference to the remarks concerning firemen and the proper maintenance of locomotives. The conclusions are as follows:

The increase in efficiency of enginemen and firemen in road service depends largely upon the employment of suitable material to fill the position of fireman. For numerous reasons proper consideration has not in the past few years been given to this matter, and this has led to diminished efficiency in coal consumption, influenced by the method generally followed of pooling the engines without proper facilities to maintain them in such handling.

The relatively large boiler results in economy, as indicated in the body of the report, not only in itself, but also economy in the engine, so that it is desirable to have as large a boiler as the limitations imposed by the engineering department will warrant for any particular design of locomotive.

The grate area of the locomotive boiler should be limited to a certain rate of combustion per square foot of grate, and small decrease in efficiency in boilers is obtained by increasing the rate of combustion within a maximum limit of 120 pounds of coal per square foot of grate per hour, yet, due to the fact that with a slow rate of combustion a milder draft will serve from the standpoint of the locomotive actually moving the train (assuming the same efficiency of firing obtains), the large grate with a slow rate of combustion has an advantage in increasing the efficiency of the engines.

The loss of fuel at delays is probably greater as the area of the grate increases and is in a measure offset by the fact that with a large grate a large engine is expected, resulting in operating fewer trains to move a given tonnage, and consequently diminishing such delays, which would have a tendency to counterbalance the increased fuel consumption due to increased grate area, leading to the conclusion that there should be a design of grate of sufficient area to give a certain rate of combustion in order to generate the requisite amount of steam to develop a given power which would be a compromise between loss due to delays and at terminals from the large grate and the loss in efficiency while running due to the small grate.

The introduction of designs of locomotives with a larger proportion of the weight on trucks and trailers has resulted in efficient performance as regards fuel economy, for both boiler and engines, has been illustrated by consideration of the B engine in the report, and generally with this design the capacity of the boiler is relatively increased in proportion to the available power developed by the cylinders (which is limited by the weight on drivers), and consequently such designs would be best adapted to give efficient performance where a relatively high horse-power is to be maintained for a comparatively long time, such as, for instance, in passenger service or in through freight service.

The relative worth of a large unit of power to a small unit warrants the maintenance of large engines to a higher standard than small engines, and to accomplish this proper facilities should be provided.

The methods of comparison of locomotives in road service from a standpoint of fuel economy should be such as to eliminate as far as possible the influence of variable conditions which might lead to erroneous conclusions from statistics now compiled, remembering that the value of fuel consumption should be proportional to the power developed by the locomotive.—American Engineering and Railroad Journal.

PROF. ARNOLD'S STEEL TESTER.

THE machine is coupled direct to a 3-horse-power motor, and motion is imparted to a vertical shaft by bevel wheel and pinion in the proportion of 4 to 1. The top of the shaft is recessed out and an adjustable nut fitted therein, which, carrying a pin, imparts the necessary to-and-fro motion to the ram *A*. The nut can be adjusted, altering the crank length, and giving 3 inches stroke and downward by thirty-seconds. The plate *B* is made a sliding fit in the ram *A*, so that full speed may be attained before the test commences.

The test piece being in position, the machine is started, when the catch *C* is dropped, and, engaging in a slot in the plate *B*, bending is commenced. The test piece is held, as can be seen in the engraving, in dies of the size required, which are clamped in a vertical sliding table, so that the length of test piece may be varied.

The lever arm *E* is connected directly by a wire to the test piece and speed counter *D*, and is held in tension by the spring *F*, its object being that, when the test piece breaks, the lever flies up and cuts off the speed counter at the same instant.

We may state that the motor can be varied between 1,400 and 700 revolutions per minute, so that the number of alternations may be varied accordingly. We illustrate the actual machine from a photograph as made by Messrs. Ibbotson & Green, Wellington Works, Sheffield.

THE CONSTRUCTION OF AUTOMATONS.

THE construction of automatons is not very difficult; they always bring under contribution only the most elementary principles of mechanics. For example, the method of constructing the singing nightingale and the smoker is as follows:

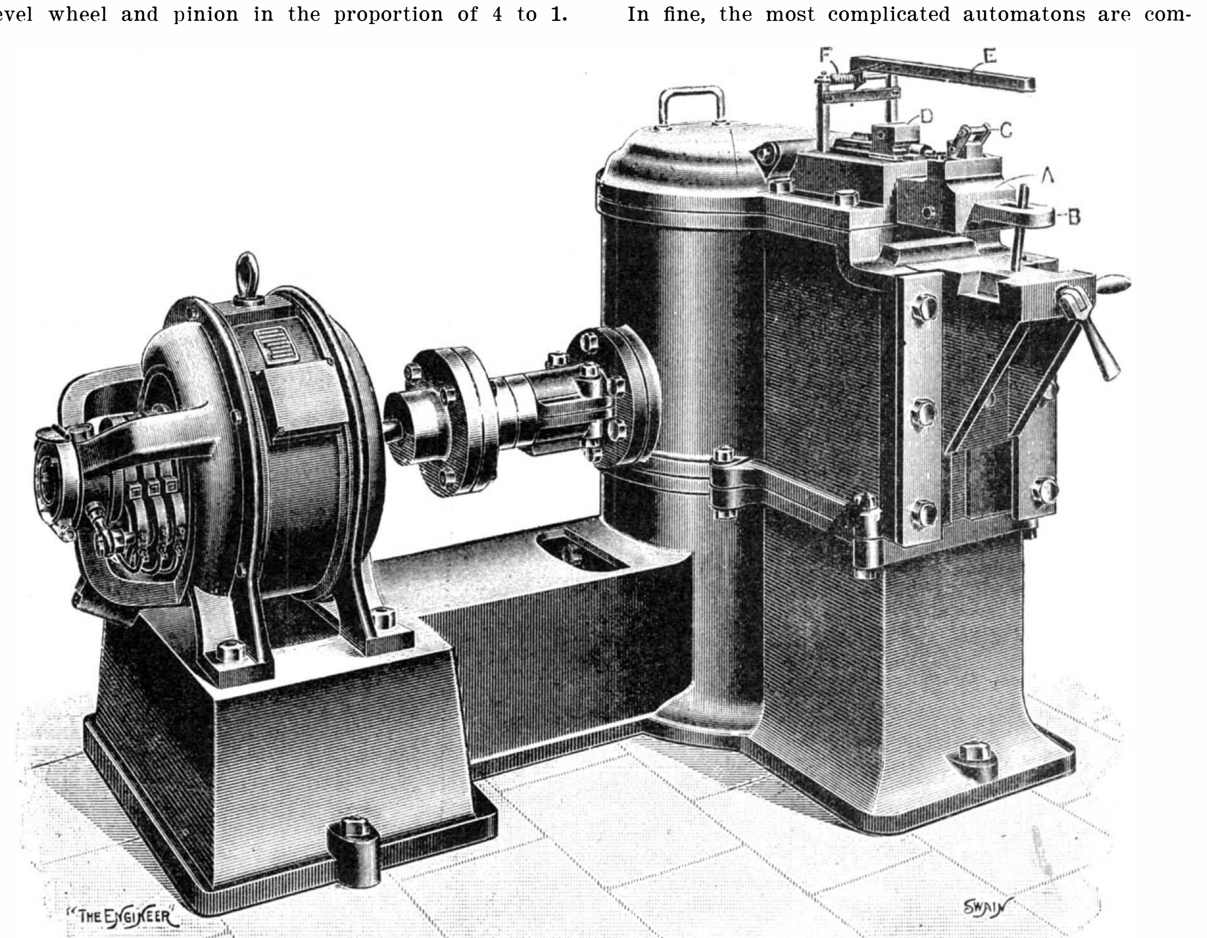
For the nightingale (or any other singing bird) it is necessary first to procure the skin of some bird, a cage, and a little metallic pipe, such as sold in the bazars for reproducing the song of a bird by a simple whistle. The bird must be perched on something representing the trunk of a tree, fastened at the bottom of the cage; this trunk is hollow and contains a small bellows, connected by a rubber tube with the whistle. In the base a movement of clockwork is concealed, of which the large wheel actuates a lever to which a wire is attached; this passes over a pulley, and is fixed by its other extremity to the upper part of a bellows loaded with quite a heavy weight.

The working of the apparatus can be readily understood. When the movement is wound the lever turns and rolls up the wire, which forces the bellows to distend and to be filled with air. On reaching the end of its course, a cam throws the lever out of gear, the weight forces the bellows to expel the air, and the bird appears to sing. When the bellows is empty, the cam puts the lever again in action, and the same effects are reproduced.

A wheel of six teeth may be added to the escapement staff, and by placing the lower mandible of the beak of the bird on a hinge, it can be made to open and shut rapidly with the aid of a wire communicating from this wheel to the hinge.

For the smoker, a hollow puppet or statuette is made use of. He can be made to smoke by a similar mechanism, with three levers actuated by cams. The smoke is produced by a mixture of ten drops of ammonia and ten drops of chlorhydric acid in a saucer concealed in the base. The clock work being put in action, the first lever causes the arm of the automaton to pivot around the hinge of the shoulder, removing the pipe or cigar from the mouth. A second lever opens the mouth and turns the eyes; finally, the third lever works the bellows, and drives the smoke through the opening of the mouth.

In fine, the most complicated automatons are com-



ALTERNATING STRESS TESTING MACHINE.

posed only of levers of calculated size, worked by cam wheels, which are actuated by a strong clock spring.—Translated from La Science Pratique.

[Concluded from SUPPLEMENT No. 1505, page 24119.]

SCIENTIFIC AGRICULTURE.*

By WILLIAM SOMERVILLE, M.A., D.Sc. DŒc.

NITRAGIN.

A FEW years ago much interest was excited in this and other countries by the announcement that the scientific discoveries of Hellriegel and Wilfarth had received commercial application, and that the organisms of the nodules of the roots of *Leguminosæ* could be purchased in a form convenient for artificial inoculation. The specific cultures placed upon the market were largely tested practically and experimentally, but the results were such as to convince even the patentees, Nobbe and Hiltner, that the problem which promised so much for agriculture had not been satisfactorily solved. Since that time, however, investigators have not been idle, and the present position of the subject is to be found in a recent report by Hiltner and Störmer.†

It was early recognized that the organisms (bacteria) which inhabited the root-nodules of the various species of *Leguminosæ* were not all alike, and that, in fact, they showed marked physiological if not morphological distinctions. Any particular species of leguminous plant is found to resist more or less successfully the attempt of these various organisms to effect an entrance into its root-hairs, and according to the power of the organism to gain access, and to establish colonies, so is the particular plant benefited and the stock of fixed nitrogen increased. This power of adaptability of the organism is designated its "virulence," a term, however, which is perhaps hardly suited to our English mode of expression, though it may for the present be retained. It has been found that organisms of what is called "high virulence" are capable of entering with ease the root-hairs of vigorous plants at an early stage of their growth, and of inducing the formation of nodules that are large, numerous, and placed high up on the roots. Organisms of low virulence, on the other hand, can only enter plants of feebler growth, or plants that have passed the most vigorous stage of youth, so that the nodules, in this case, are small and scarce, and distributed, for the most part, near the ends of the roots. The practical object, therefore, would appear to be the breeding of strains or varieties of organisms of high virulence, adapted to the symbiotic requirements of the various important species of farm and garden leguminous crops.

The nitragin put on the market a few years ago was used in two ways, being either applied directly to the fields, or mixed with water and brought into contact with the seed before sowing. Under the former method of procedure an increase of crop was obtained only when the nitragin was used on land containing much humus. The explanation given for failure under other conditions was that the bacteria artificially introduced perished for want of food before the leguminous seed germinated and produced plants.

Failure of the nitragin to effect an improvement in the crop when it was sprinkled on the seed is now believed to be due to the action of secretions produced by the seed in the early stages of germination. These secretions are found to be rich in salts of potash, and when brought into contact with the bacteria in question they induce changes allied to plasmolysis, and these changes are subsequently followed by death. This difficulty was found to be got over by moistening the seed and allowing it to sprout before the nitragin was applied; but manifestly such a procedure would always be difficult, and often impossible, to carry out in practice. The object, however, would appear to have been gained in another way, namely, by cultivating the bacteria in a medium that imparts to them the necessary power of resistance. Such nourishment may take various forms, but that which gave the best results consisted of a mixture of skim milk, grape sugar and pepton, and it is in this medium that the organisms of the nitragin now distributed are cultivated.

Early in the present year the new nitragin was being offered free of cost to all members of the German Agricultural Society on the condition that it be used in accordance with the directions that accompany it. In consequence of the large demand the free offer was in April withdrawn, but the substance may be purchased from Prof. Hiltner, of Munich, in quantities sufficient to treat the seed of a half to one acre at the price of one shilling. The United States Department of Agriculture are so convinced of the practical utility of the improved nitragin that they are distributing large quantities to American farmers. In this way the material will be thoroughly tried in two hemispheres under practical conditions, and abundant evidence should soon be forthcoming as regards its effects. It is to be hoped that British investigators will not be deterred by past disappointments from putting the new form of nitragin to the test.

IMPROVEMENT OF VARIETIES OF CROPS.

Speaking generally, the attention of agricultural investigators during the past fifty years has been directed more to manurial and similar problems than to the improvement of the yield of crops through the agency of superior varieties. This, it seems to me, is the outcome of the tradition that agricultural science is based upon chemistry, using the term in its old-fashioned and restricted sense, and as a consequence farmers have looked principally to the chemical laboratory for light and leading. It is true that much excellent work has been accomplished from the botanical side, but this has been performed rather by farmers, seedsmen, or amateurs, than by trained botanists. But fortunately the botanist is now getting his opportunity, and the possibilities before him are sufficiently attractive.

Judging by the results that have been obtained, it would appear that wide divergences as regards yield, nutritive qualities, resistance to disease, and other important properties exist between varieties of the same plant-species; so much so, in fact, is this the case that attention to the relationship between variety and locality would appear to be one of the most important matters to which a farmer can give consideration. But it has been found that new varieties are frequently unstable, reverting rather rapidly to an unsatisfactory form, or displaying a lack of power of resistance to disease. It therefore becomes necessary constantly to be producing new varieties to take the place of those that are worn out, and it seems reasonable to anticipate that the professional botanist will take a much larger part in this work than has been the case in the past.

Not only is the yield of a crop greatly influenced as regards quantity and quality by the variety of seed employed, but, as is well known to practical farmers, the local origin of the same variety of seed has a marked influence on many properties of plants (vigor, resistance to disease, and resistance to frost, and to weather generally), and these properties quickly react on the yield. In this country we have a prejudice in favor of the seed of English-grown red clover, Provence lucerne, Scotch potatoes, Belgian flax, Ayrshire ryegrass, pine and larch from Scotland, Norfolk and Cambridge barley, Warp-land wheat, etc., and there seems no reason to doubt that such preferences are based upon sound experience. This subject would appear to be one that is still full of interesting and important possibilities, and last year I had the opportunity of seeing some striking results in a new and unexpected direction. During the past few years the Austrian experimental forestry station at Mariabrunn has given much attention to the influence of the local origin of the seed on the resulting trees, especially the common spruce, and, although it is too early to pronounce a final judgment on the results, these are already so conspicuous as to warrant my placing some figures before you.*

In the autumn of 1896 a supply of seed was obtained from certain definite localities, the trees that yielded it being of varying dimensions and situated at various altitudes. The seed was sown in the spring of 1897 in the nursery attached to the station, and, having been transplanted into lines, a portion of the young trees are growing there now. Others were, in 1899, planted out in a wood (Loimannshagen) in the neighborhood. In the autumn of 1902 the young trees were carefully measured, with the folllowing results:

Locality of Origin of the Seed	Height above Sea-level of the Mother-tree	Average Annual Height-growth of the Mother-tree	Average Height (1902) of the Young Trees		Average Growth in Height of the Nursery Trees in 1902
			In the Wood	In the Nursery	
	meters	cm.	cm.	cm.	cm.
Piesendorf, Salzburg.....	1,400	24	62	85.2	34.7
" "	1,750	14	47	61.6	23.3
St. Andiä in Kärnten. . .	1,420	25	57	71.1	27.1
" "	1,625	18	41	51.2	18.4
" "	1,650	15	35	39.1	14.2
Treibach, Kärnten	900	28	56	81.6	30 7
" " . . .	900	29	53	80 9	29.7
Achenthal in N. Tyrol .	900	31	64	87.9	29.0
" " .	1,300	28	67	80.5	27.9
" " .	1,600	26	50	62.2	21 8

These figures show:

(1) That where, in any particular locality, mature trees were measured at different elevations, the tallest trees, as was to be expected, were found at the lowest elevation.

(2) That where the seed of such trees was sown the height of the resulting trees, at the age of six years, was in close relationship to that of the mother trees.

(3) That where mother trees of approximately equal height from the same locality and the same elevation (Treibach) were selected, the resulting progeny were also of approximately equal vigor.

The differences in the height-growth of the young trees are so striking as to lead to the conclusion that the financial returns of forestry operations may be profoundly modified by the origin of the seed, and it would apparently pay nurserymen and planters well to give their careful attention to this subject.

JOINT OR CO-OPERATIVE WORK.

In conclusion, I may be allowed to direct your attention to a prominent feature of experimental or demonstrational work which is found to exhibit itself in all countries of the world where serious attention is given to the improvement of agricultural production. While, no doubt, it is the individual who plants the germ of a new idea and fosters its growth until it is fairly established, it is by systematized co-operative effort that the practical value of the idea is tested, and that the knowledge is made available and acceptable to the workaday farmer. Various objections have been urged against field experiments, and it need not be denied that they are incapable of supplying a satisfactory answer to many scientific questions. Such experiments are exposed in no small degree to the disturbing influences of inequalities of soil, irregular cultivation, the attack of animals, and the vicissitudes of climate; but when reasonable precautions are taken to guard against these, and given a sufficient number of tests, the results of field trials are of the highest value as a guide to practice. Apart from attention to the preliminary details of the scheme, and to care in carrying it out, the main point to aim at in field trials is to have them so frequently duplicated or repeated that the disturbing factors inseparable from field work will be largely eliminated. Such duplication may take the form of repetition of the same test on the same area year after year, when one obtains some such series of results as those that have helped to make the reputation of Rothamsted. But however convincing may be the results of a series of experiments that have marched majestically on for half a century, they lack attractiveness for the investigator who desires to solve not one but many problems during his lifetime. For him, therefore, duplication in time gives place to duplication in space—in other words, he secures the same end, or an end that is in many respects equivalent, by repeating the test at several places in the same season, or in a short series of seasons. This method of work is, of course, by no means new. It was utilized with great advantage by the late Dr. Voelcker, and by our more recently departed friend, Dr. Aitken, and it is a line that is still being followed by the two great societies with which these distinguished workers were so long associated. The method is also being practised extensively, chiefly through the agency of societies, in Germany, France, and other European countries, and it has taken firm hold in the United States and in some of our colonies. One of the largest and most successful agencies in co-operative demonstrations is to be found in Canada, where, during the past nine years, an average of 37,000 farmers have annually received small parcels of improved seeds through the government experimental organization directed by Dr. Saunders. It is claimed that the financial results to the country as a whole run to many millions of dollars, and there seems to be no reasonable doubt as to the accuracy of the statement.

I trust you will pardon my referring in this connection to a matter that is personal to a considerable proportion of this audience, and of saying that, in my opinion, one of the best pieces of work that has been done in this country in recent years is the preparation of the scheme of joint experiments by the Agricultural Education Association. The problems set for solution under that scheme are of the simple, direct, practical kind that field work is thoroughly qualified to deal with. But the essence of success lies in the power of numbers, and the control of this factor rests with the members of the association themselves. Now, most of the members of that association are not only investigators but also teachers, and many of the institutions that they represent have recognized the advantages of keeping in touch with their past pupils through the agency of collegiate associations. These old students, it seems to me, represent a large mass of most valuable material for carrying through co-operative experimental work of the class referred to, and I am convinced that the agriculture of the country would benefit in no small degree were this powerful agency fully utilized.

* Read before the British Association for the Advancement of Science.

† "Bericht über neue Untersuchungen über die Wurzelknöllchen der Leguminosen und deren Erreger," Arbeiten aus der Biol. Abteil. für Land- und Forstwirtschaft am K. Gesundheitsamte, Band iii, Heft 3.

* "Programm der vierte Versammlung des Internat. Verbandes Forstlicher Versuchsanstalten zu Mariabrunn," 1903, p. 47.

ANCIENT EGYPTIAN MONUMENTAL COLORS.

DESPITE their extreme old age, in spite of the long time that these colors have been exposed to the influences of the weather, they are yet so brilliant and fresh that it is scarcely conceivable that they have endured for thousands of years.

Of what then did these astonishingly durable colors consist? With few exceptions the ancient Egyptians made them of minerals.

The ever-present brownish red, corresponding to the so-called Pompeian red, was a mixture of ferric oxide and clay from the Egyptian red iron-ocher beds. The beautiful fine grain of this iron color was no doubt obtained by long grinding in water and washing out.

As for the yellow color, besides gold bronze and leaf gold, ferric oxide was also made to serve, this being mixed, according to the shade desired, with variable masses of alumina, lime, and the like.

By heating these last mixtures, the brown tints were obtained, and the orange shades by adding red.

The ancient Egyptians obtained their blue colors from glass fluxes containing copper, which were probably plunged while yet hot into cold water, when they became cracked and seamed, and so brittle that they were easily ground to powder and levigated. In order to cause this glass flux powder to take hold upon the surface to be colored, some suitable binder was pressed into service.

Gypsum was used for white, tinted with some organic substance, probably madder red, for pinkish and pale-red tones.

The durability of these colors must have been well known to the builders and decorators of that day, for this is indicated, if not proven, by an inscription written by a builder of the Pyramids, Neh-Fermed, and placed there 4,000 years before Christ. It proudly proclaims that "All color decorations for the Temple must be as everlasting as the Gods themselves."—Berliner Maler Zeitung.

ELECTRICAL NOTES.

The first of the new motor-cars for the Paris Metropolitan have been completed. They have been considerably improved over the existing type and special precautions have been taken toward preventing fires. The cars are longer and better lighted. The front cabin, which is occupied by the motorman and apparatus, is large and well arranged. One point to be noted is that this compartment is completely isolated from the next by a double partition with an 8-inch air space. The remainder of the car contains seats and standing space for the passengers. The partitions are covered with sheet iron to prevent fire. The cars are 35 feet long and have three doors opening from the sides instead of two, as before. They are well ventilated by windows in the ceiling. The cars are mounted upon two trucks of two axles each. A 175-horse-power Westinghouse motor is placed on each truck, giving 300 horse-power per car. A train of three motor cars and three trailers will thus dispose of 1,050 horse-power. The train will weigh 154 tons. The greatest precautions have been taken to prevent short circuits. The new motor uses asbestos and mica insulation entirely and is practically fireproof. This is a new departure in motor design, and it has been successfully carried out at the company's works at Havre. All the cables are laid upon fireproof material or inclosed in asbestos covering surrounded by iron pipe.

In order more closely to investigate the phenomena attending the disruptive discharge of a Ruhmkorff coil, Mr. F. Lifchitz, as recorded in a paper recently presented to the Russian Physico-Chemical Society, places a concave mirror on the axis of the Ducretet commutator working the coil. On account of the synchronism, a fixed image of the spark is obtained on the screen instead of a Federsen band, as obtained in the case of the rotation of the mirror being much more rapid. The image observed is a single one in the case of the spark length being maximum, 2, 3, etc., images—up to some dozens—being realized as the distance of the electrodes from the spark becomes less. In order to be able to record these observations, the author fitted a photographic plate instead of the mirror vertically to the axle of the commutator, when the images of the sparks followed up each other at increasing intervals, beginning with 1-16,800 second. This goes to confirm Hertz's opinion, according to which the discharge of the coil would carry an amount of electricity much greater than that of an electrostatic machine in virtue of the more rapid increase in potential. The number of impulses obtained for the same length of spark varies directly as the intensity of the current traversing the primary circuit. Now let the commutator of the coil be replaced by a microphone acted upon by the voice of the experimenter. Each letter pronounced will result in a series of disruptive discharges, the series of impulses being the longer as the pulsations are stronger. The vibration thus set up may be received by the aid of a decoherer. A whole series of vibrations following up each other at intervals of some ten-thousandths of a second will result in a single variation in the resistance of the decoherer, being the greater as the series is longer, and the time necessary for producing decoherence being of some thousandths of a second.

A correspondent of (London) Nature refers as follows to a method and apparatus for the electrical transmission of pictures and script lately described by Dr. Arthur Korn: The problem of distant electrical vision is one to which much speculation and experimenting have been devoted. Before this problem can be attempted with any hope of success, however, the preliminary one of the electrical transmission of photographs over a distance has to be solved. This problem, it may be stated at once, has been mastered, and it is now possible to transmit photographs in this manner, and successful results have been obtained over telegraph and telephone lines 800 kilometers long. It does not need much consideration to see how important such a process would be for journalistic and police work if it could be industrially exploited, and it were possible simply to hand a sketch or photograph in at the telegraph office and send the same as one now sends an ordinary telegram. The evening papers would be able then to publish photographs taken at the seat of war in Korea on the same day. Unfortunately, with the apparatus at present to be had, the time taken to transmit a half-plate photograph is half an hour. The cost of the use of a telegraph line of any length for half an hour would be, it is needless to point out, prohibitive. The lessening of the required time of transmission is, however, simply a matter of further development, and no good reason can be seen why in a few years' time the process should not be an adjunct to every existing telegraph line. The method shortly consists of the following: A ray of light is made to pass systematically all over the transparent film to be transmitted. After passing through the film it impinges upon a selenium cell the resistance of which varies proportionately to the amount of light which passes through the photograph. These varying currents pass through the line and are received in a moving coil galvanometer the pointer of which, in moving, inserts or takes out resistance in a high tension circuit, according as the current flowing in the moving coil changes. In the high tension circuit a small vacuum tube is connected, and it follows that the illumination of this tube is proportional to the light passing through the plate at the transmitting end of the line. This vacuum ed photographic paper in synchronism with the ray of light over the transmitted plate, and thus a reproduction of the same is obtained. The transmitted film and sensitized paper are each wrapped on a glass cylinder. These cylinders are rotated by motors, and synchronized once each revolution. Only one wire is needed for the transmission, with, of course, an earth return. In the case of the transmission of handwriting and half-tone illustrations, the same are got up on metal foil with electrical non-conducting ink. A conducting point then travels over the metallic foil, and closes and opens the sending circuit according as it is traveling on a marked or unmarked place. The receiver used by the author is a modification of that described above, the essential point being the use of the vacuum tube fed with the Tesla currents. The speed reached is 500 written words per hour. For a half-tone illustration a strip ½ centimeter wide and 10 centimeters long can be sent in 100 seconds. It would seem that there is not very much practical value in the transmission of handwriting; the type-printing telegraph of to-day fulfills all ordinary requirements, and it would be only very seldom that a transmission of handwriting would be required. It is to be hoped, however, that this electrical "distant photography" will make rapid progress.

SELECTED FORMULÆ.

Alloys for Small Casting Molds.—Tin 75 parts and lead 22 parts, or 75 parts of zinc and 25 parts of tin, or 30 parts of tin and 70 parts of lead, or 60 parts of lead and 40 parts of bismuth.

To Deaden Amalgam Gilding.—Mix together 46 parts of potash alum, 46 parts of saltpeter, 3 parts of sea salt, and 5 parts of water. Any objects to which it is desired to impart a dull color are to be covered with this mixture and heated over a fire or flame until the coating becomes nearly transparent, then removed from the heat and plunged into cold water, finally rinsed in hot water, and dried in clean sawdust.

To Silver-plate by Means of Zinc Contact.—According to Buchner, 10 grammes of silver nitrate is dissolved in water and precipitated by the addition of hydrochloric acid in the form of silver chloride, which is washed several times in clean water; now dissolve 70 grammes of spirit of sal-ammoniac in water, and add to it 40 grammes of soda crystals, 40 grammes of pure potassium cyanide, and 15 grammes of common salt. Now thin down the compound with sufficient distilled water to make a total of 1 liter.

Small brass objects may be silvered after boiling clean and by means of zinc contact in a solution produced in the following manner: Dissolve 10 grammes of lunar caustic in water and add to it 10 grammes of potassium cyanide, 17 grammes of common salt, 15 grammes of potassium carbonate, 10 grammes of yellow prussiate of potash, adding enough water to make a total amount of 1 liter of liquid.

A silver-plating solution for iron, steel, copper, and brass, according to Böttcher, consists of 2 parts of hyposulphite of silver, 1 part of sal-ammoniac, and 20 parts of water.

A preparation which is pre-eminently adapted for silvering all kinds of metals is the composition according to Kayser: Take 11 parts of lunar caustic, 20 parts of hyposulphite of soda, 12 parts of sal-ammoniac, 20 parts of whiting, and 200 parts of distilled water. Mix them all intimately together and plunge the well-cleansed objects into the bath.

To gild copper and brass (iron, steel, tin, and zinc must be previously coated with copper) by the boiling method, the following bath according to Langbein is well adapted: Dissolve 1 gramme of chloride of gold and 16 grammes of potassium cyanide in 250 grammes of water; dissolve also and separately, 5 grammes of sodium phosphate and 3 grammes of caustic potash in 750 grammes of cold water. Mix these solutions and bring them to a boil. If the action subsides, add from 3 to 5 grammes more potassium cyanide. The polished iron and steel objects must first be copper-plated by dipping them into a solution of 5 grammes of blue vitriol and 2 grammes of sulphuric acid in 1 liter of water. They may now be dipped into a hot solution containing 6 grammes of gold chloride and 22½ grammes of soda crystals in 75 grammes of water. This coating of gold may be polished.

Gilding by means of zinc contact may be accomplished with the following formula: 2 grammes of gold chloride, 5 grammes of potassium cyanide, 10 grammes of sulphite of soda, and 60 grammes of sodium phosphate are dissolved in 1 liter of water. When used the bath must be hot. A cold bath without the addition of potassium cyanide may also be used for gilding, and this consists of 7 grammes of gold chloride, 30 grammes of yellow prussiate of potash, 30 grammes of potash, 30 grammes of common salt in 1 liter of water.

To gild zinc objects, dissolve 20 grammes of gold chloride in 20 grammes of distilled water; dissolve also 60 grammes of potassium cyanide in 80 grammes of water. Pour the two together, stir well several times, and filter. Add now 5 grammes of tartar and 100 grammes of finely-powdered chalk. This paste is applied with a brush. Copper or brass articles must first be coated with zinc. To do this, proceed in this wise: Bring a concentrated solution of sal-ammoniac, to which a certain amount of zinc filings has been added, to a boil, and hang or throw the well-cleansed objects into it, allowing them to remain until they are covered with a uniform coating of zinc; or boil the articles in a concentrated solution of caustic soda containing a given amount of zinc filings.

A thin plating of antimony may be applied to articles of brass, copper, iron, silver, etc. Brass goods in particular take on a beautiful steel-gray color, resulting from a thin coating of metallic antimony, by dipping them into a solution of chloride of antimony.—Deutsche Goldschmiede Zeitung.

ENGINEERING NOTES.

The largest locomotive repair contract ever undertaken is said to be one just concluded between the Erie Railroad and the American Locomotive Company, for the repair of 600 locomotives at the shops of the latter company. This covers about half the motive power owned by the Erie Company.

The Pennsylvania Railroad Company has recently laid down, on the curves of the Delaware Avenue freight line in Philadelphia, a number of rails weighing 142 pounds to the yard. These are claimed to be the heaviest steel rails ever made, the largest heretofore rolled having been 125 pounds.

M. Heit, a French inventor, has recently patented a compass which automatically registers minute by minute. The compass card is fixed on a steel pivot, which rests on a fixed agate, instead of having at its center an agate resting on a fixed steel point. The fixed agate is immersed in a drop of mercury, which serves as a conductor for the electric current that causes the movements of registering.

A locomotive-testing laboratory similar to the plant at the St. Louis Exhibition is to be added next year to the equipment of the Charlottenburg-Berlin Technical University. None of the locomotive builders have offered to present an engine, as was done for Purdue University, but instead arrangements have been made with the Prussian State Railway Administration to lend locomotives.

The railways of the United States employed during 1903 no less than 1,189,315 men, of whom 41,071 belong under the general head of administration, 399,592 were under the departments of maintenance of way and structures, 228,280 under maintenance of equipment, 518,390 were engaged in conducting transportation, and 1,982 were unclassified. The total number of employes worked out at 5.94 per mile of line in operation.

The greater number of Swedish steamship owners, representing altogether 249 vessels, have addressed a memorial to the government, requesting them, in some form or other, to reserve to Swedish merchant ships the immense export trade in Swedish ore. The memorialists point out that in almost all the great maritime countries the transport of certain indigenous products is secured for vessels under the national flag, partly by means of reduced harbor dues, and partly by means of state aid.

Tests of concrete-steel beams are now assuming such an important place in engineering investigations that the paper by Prof. Turneaure will doubtless receive careful study by many readers. One of its features relates to the manipulation of such tests in order to detect the earliest cracks in a beam. For this purpose the load is so applied that the upper surface of the beam is in tension, and the concrete is kept moist. The moisture indicates the presence of an incipient crack before it can be detected otherwise, for the appearance of a crack is foretold by a narrow wet streak which later becomes a dark hair-like crack. As a result of this delicate indication of cracking, Prof. Turneaure is able to place the elongation of the concrete at the time of the first visible cracks at a much smaller figure than that given by previous observers. As a result of this, it further seems that rupture really begins with about the same elongation irrespective of the presence of steel reinforcement in a beam. With plain concrete failure occurs at once, while with reinforced concrete failure is very slow, or, to quote Prof. Turneaure, "the steel develops the full extensibility of a non-homogeneous material that otherwise would have an extension corresponding to the weakest section."—Engineering Record.

The utilization of steam-turbine exhaust for heating should not be passed by. On the assertion of the operating engineer, who was also responsible for the installation, the statement is made that the exhaust steam from the turbine when operated condensing is sufficient in amount to heat the building, a vacuum of 26 inches being possible under the conditions. It is difficult, however, to check these results on the basis of the load stated, 600 amperes at 120 volts, in the light of the fact that the building has nearly 1,500,000 cubic feet of space to be warmed. Buildings of the size in question frequently require at least 3,500 pounds of steam per hour in cold weather, or say, for the sake of wide latitude, 3,000 pounds of steam, or 3,000,000 B. T. U. Against this is a supply of exhaust steam from a unit developing in winter 100 E. H. P. at 14.5 pounds per electric horse-power per hour, or a supply of 1,500 pounds of steam, assuming no condensation in the turbine exhaust. This, with 26-inch vacuum, is equivalent to 1,540,000 B. T. U. Evidently, then, but one-half of the steam required will be furnished through the turbine. Moreover, the fan-system heater coils in place aggregate 4,830 square feet of heating surface, and while these were purposely chosen large—as were other adjuncts of the plant, as explained in the descriptive account—the pipe-coil surface would need to give off heat only at the rate of 310 B. T. U. per square foot per hour to effect complete condensation of the exhaust steam.—Engineering Record.

TRADE NOTES AND RECIPES.

A Powder for Hardening Iron and Steel.—For wrought iron place in the charge 20 kilogrammes of common salt, 2 kilogrammes of potassium cyanide, 0.3 kilogramme of potassium bichromate, 0.15 kilogramme of broken glass, and 0.1 kilogramme of potassium nitrate for casehardening. For cooling and hardening cast iron: to 60 liters of water add 2.5 liters of vinegar, 3 kilogrammes of common salt and 0.25 kilogramme of hydrochloric acid. A Powder for Tempering Steel: *a*. Use animal charcoal produced by charring horn 24 parts, 4 parts of horn filings, 6 parts of glue, 9.5 parts of potassium nitrate, and 55 parts of common salt. *b*. 1 part of potassium bicyanide, 1 part of purified saltpeter, 1 part burnt and powdered cattle hoofs, 1-30 part of gum arabic, 1-30 part of aloes, and 0.5 part of common salt. Mix *a* and *b* well together after being well pulverized, strew this upon steel when red hot and upon wrought iron when white hot, and allow it to burn in, after which cool as usual.—Neueste Erfahrungen und Erfindungen.

Mahogany Stain for Wood.—

I. Rub the wood with a solution of nitrous acid, and then apply, with a brush, the following:

Dragon's blood	1 ounce
Sodium carbonate	6 drachms
Alcohol	20 ounces

Filter just before use.

II. Rub the wood with a solution of potassium carbonate, 1 drachm to a pint of water, and then apply a dye made by boiling together

Madder	2 ounces
Logwood chips	½ ounce
Water	1 quart

III. Mordant the wood with dilute nitric acid and apply the following:

Alkanet	½ ounce
Aloes	1 ounce
Dragon's blood	1 ounce
Alcohol	1 pint

—Drug. Circ. and Chem. Gaz.

Ox-gall Soap for Cleansing Silk Stuffs.—To wash fine silk stuffs, such as piece goods, ribbons, etc., one cannot do better than employ a soap containing a certain amount of ox-gall, a product that is not surpassed, if indeed it have an equal, for the purpose. In making this soap the following directions will be found of advantage: Heat 1 pound of cocoanut oil to 30 deg. R. (100 deg. F.) in a copper kettle. While stirring vigorously add ½ pound of caustic soda lye of 30 deg. Bé. In a separate vessel heat ½ pound of white Venice turpentine, and stir this in the soap in the copper kettle. Cover the kettle well, and let it stand mildly warmed for four hours, when the temperature can be again raised until the mass is right hot and flows clear; then add the pound of ox-gall to it. Now pulverize some good, perfectly dry grain soap, and stir in as much of it as will make the contents of the copper kettle so hard that it will give little to the pressure of the fingers. From one to two pounds is all the grain soap required for the above quantity of gall soap. When cooled cut out the soap and shape into bars. This is an indispensable adjunct to the dyer and cleaner, as it will not injure the most delicate color.—Illustrirte Zentral Blätter.

Chinese Blue.—The Standard Dictionary gives China blue as a synonym for "soluble blue," and Chinese blue as a synonym for Prussian blue.

A "soluble blue" has for many years been readily obtainable in commerce which is similar in appearance to Prussian blue, but, unlike the latter, is freely soluble in water. This blue is said to be potassium ferri-ferrocyanide.

If the pharmacist wishes to prepare it himself, instead of buying it ready made, he may do so by gradually adding to a boiling solution of potassium ferricyanide ("red prussiate of potash") an equivalent quantity of hot solution of ferrous sulphate, boiling for two hours and washing the precipitate on a filter until the washings assume a dark-blue color; the moist precipitate can then at once be dissolved by the further addition of a sufficient quantity of water. About 64 parts of the iron salt is necessary to convert 100 parts of the potassium salt into the blue compound.

If the blue is to be sent out in the liquid form it is, of course, desirable that the solution should be a perfect one. To attain that end the water employed should be free from mineral substances, and it is best to filter the solution through several thicknesses of fine cotton cloth before bottling; or if made in large quantities this method may be modified by allowing it to stand some days to settle, when the top portion can be siphoned off for use, the bottom only requiring filtration.

The ball blue sold for laundry use consists usually, if not always, of ultramarine. Balls or tablets of this substance are formed by mixing it with glucose or glucose and dextrin, and pressing into shape. When glucose alone is used, the product has a tendency, it is said, to become soft on keeping, which tendency may be counteracted by a proper proportion of dextrin. Bicarbonate of sodium is added as a "filler" to cheapen the product, the quantity used and the quality of the ultramarine employed being both regulated by the price at which the product is to sell.

As the mixing and compression process is somewhat troublesome, it may pay better to purchase the balls or cakes from the manufacturer or jobber in large packages and put them up from these into small cartons, as this operation will usually yield much of the profit to be derived from the sale.—Drug. Circ.

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