SCIENTIFIC AMERICAN SUPPLEMENT

Copyright 1916 by Munn & Co., Inc.

VOLUME LXXXII
NUMBER 2117

★NEW YORK, JULY 29, 1916★

10 CENTS A COPY
$5.00 A YEAR

Movable coal-handling derrick that swings the loaded cars directly over the hatchway of the vessel.

METHODS OF HANDLING COAL IN ENGLAND.—[See page 72.]

Automobiles in the Great War—I*

Types of Cars Used and Technical Details Considered in the Light of Experience

By W. F. Bradley†

ALTHOUGH a tempting subject, and one on which comparatively little reliable information has been published, it is not intended in this paper to detail all the uses to which automobiles are being put in this war. On the Allied front in France, from the North Sea to the Swiss frontier, there are no doubt 60,000 army automobiles of all kinds. It is known too that there are 24,000 American trucks in service with the Allies.

Before August, 1914, it was realized that automobiles would play a prominent role if the nations of Europe went to war. In the annual maneuvers some nations had gone so far as to abolish the use of horses in the supplying of food and ammunition to an entire army corps, and had found the experiment to be successful. But no single expert, either military or automobile, appears to have foreseen the extensive use of automobiles to be developed within a month of the outbreak of war. In all their preparations, it is certain that the war authorities had never contemplated having to go outside Europe for their supply of automobiles.

Yet the war had not been in progress more than a month before France, the nation that had most carefully studied the use of automobiles in war, had sent an official to the United States with instructions to buy several thousand trucks; England, with a greater number of commercial vehicles than any other nation, was also anxious to supplement her military fleet with trucks from across the Atlantic. The trucks available were ordinary commercial vehicles, built for commercial conditions in the United States, without their designers or manufacturers ever having conceived that they might some day be employed in war service. These purely commercial trucks were put to work side by side with the more specialized European machines, and although they were all open to improvement in some or many respects, they all gave—and are still giving—good service in the war zone.

From this it must not be assumed that any ordinary truck is fit for war work, that there are no special military requirements, and that no lessons have been learned during nearly two years of war. The point to be enforced is the uselessness of trying to develop a special type of automobile truck to meet purely military requirements, without any consideration of commercial service. Of necessity a certain number of purely military automobiles will differ from the commercial truck as much as a battleship differs from a cargo boat; but the great bulk of the automobile trucks for any future war will be the commercial trucks of the nations involved.

PART PLAYED BY SUBSIDY VEHICLES.

Before the war the British authorities had designed a subsidy type of truck. Admittedly a good vehicle for military purposes, it had been designed with such disdain of commercial service that few business houses would purchase it. When England went to war less than fifty of these army subsidy trucks were to be found in the whole of Great Britain. Then the requisition officers gathered in practically everything on wheels. It was a jump from one extreme to the other, for many of these hastily requisitioned trucks never got within sound of the guns.

The French system was much less drastic. The military authorities, instead of saying dogmatically what were and what were not good features of army truck design, left these matters largely to the engineer and were content principally with imposing working conditions. If a truck could fulfill those conditions, it would be accepted as an army subsidy vehicle, no matter whether it had worm or chain drive, whether its motive power was obtained from steam, gasoline, electricity, or from a combination of these. In the end this tended towards uniformity, for it automatically eleminated unsuitable types. But it did not bar a manufacturer who failed to see eye to eye with the military expert on the question of final drive, or who refused to give up his preference for a particular type of wheel bearing or gearbox.

The problem was, and ever will be, one of directing design into such channels that the whole of the nation's commercial trucks could be applied to purposes of war. This application must be possible, however, without interfering with the primary usefulness of the trucks as commercial vehicles. It is a matter of compromise. If the truck is highly specialized for some class of commercial work, it will probably not be of great value on war duty; if it is designed only to meet military requirements, the ordinary customer will refuse to buy it, either with or without the offer of a subsidy.

For instance, in France it was considered that the most suitable military type was a 2-ton truck. But the commercial user was not satisfied with a 2-tonner and would have preferred a vehicle with a 5-ton load capacity. Thus a compromise was struck with 3½ tons, and it is this capacity of truck that has proved most suitable under actual war conditions. It is not so light as to be constantly threatened with overloading; it is capable of hauling one or more trailers; and its dead weight is sufficiently low to enable it to operate over poor road surfaces. For the general conditions of war service the 5-ton truck has too great a dead weight.

For certain special classes of work it has been found that a 4-ton truck gives the most efficient service. This model has not been produced in great quantities in Europe, and, curiously, is not found in America. Manufacturers in the United States have specialized on 3-ton models, but have not produced any intermediary model between this and the 5-ton truck. The demand for a 4-tonner is comparatively recent; it does not alter the general statement that the bulk of the work is best done by the 3½-ton vehicles.

Light weight, consistent with strength, has been shown to be essential. The French truck, as it had been developed up to the eve of war, had to weigh not more than 3½ tons (7,716 pounds) this including the entire truck with its body, water, gasoline, oil and hoops capable of receiving a suspended load of 2,645 pounds. In reality the weight was nearly always below the maximum, some of the trucks scaling as low as 5,730 pounds and the average being just under 6,200 pounds. The tendency since the war has been toward a further reduction in weight. Such bodies are of the platform type with movable sides and detachable canvas top on reinforced hoops, the hoops being used to carry a portion of the load—generally wounded men.

FOUR-CYLINDER ENGINES SATISFACTORY.

Four-cylinder engines are insisted on, and these have been found quite sufficient for all ordinary purposes. Some of the heavy tractor engines have 6 cylinders, but their number is small. The French military authorities have never made any attempt to impose cylinder dimensions. It was in the interests of the manufacturers to get the smallest engines capable of doing the work, for fuel consumption was taken into consideration. The small engines of two or three years ago have, however, been found unsatisfactory. Moreover, the requirement that each truck should be capable of hauling a fully loaded companion up a macadamized 8 per cent gradient, has tended toward a slight increase in piston displacements, and also toward certain modifications in gear ratios. Statistics of 18 different makes of French army type trucks that went into service August, 1914, show that the average bore was 3.9 inches and the average stroke 5.7 inches. The biggest engine measured 3.9 by 6.69 inches and the smallest 3.5 by 5.5 inches, bore and stroke, respectively.

All engines are carried under a hood. There has been a tendency toward this for several years; but the war has shown its advantage over the under-the-seat position so clearly that the latter will no longer be accepted. There are a few exceptions, which only tend to prove the rule, notable among them being the Paris omnibus type of chasis. These vehicles, however, are used exclusively for carrying troops. On such work the greatest possible body area is required.

In passing, it may be mentioned that the internal-combustion engine has proved itself without a rival for military transportation. No gasoline-electric systems have made good. The tendency is toward a reduction in the number of steamers. Even the British, who have always shown a partiality toward steam, are making comparatively little use of it in France, although steam tractors are much in evidence around the camps of England.

MANY TYPES OF FINAL DRIVE.

Under the French military regulations every type of final drive was admitted; the English military subsidy specification called for worm drive. Those partisans who looked to the war to settle the question of final drive are likely to be disappointed. At present automobile trucks are in service on the front with straight bevel drive, double reduction bevel, worm, internal gears, and side chains with and without housings. No one type has shown itself incontestably superior to all the others, and so far as it is possible to estimate their opinion, the higher authorities have no intention of imposing the adoption of any particular type of final drive. The automobile department of the French army has carefully compiled statistics dealing with parts supplied to trucks in service, but it is likely they will be used only to determine the makes that have been most economical and satisfactory, and not which type of design is superior. These data are closely guarded, and even if given out would be useless without explanations. One poorly built make of truck would be quite sufficient, for instance, to discredit a particular type of final drive if statistics were examined without a complete understanding of them.

While the question of final drive will remain unsolved by the war, it being left to commercial users to work out this problem, the writer is of the opinion that chain drive will gradually disappear before worm, internal gear, and double reduction bevel axles. This is not intended to infer that the chain has given more trouble than its rivals. It is represented in the French army by White, Packard, Berliet, Clement-Bayard, Rochet-Schneider, Sauer, Fiat and Delahayne trucks. These makes have given as good service as any others, but the impressions remains, and is probably correct, that the chain is less mechanically efficient, when new, than some other types of drive; its efficiency is certainly less under some conditions of operation. The ease with which the chain can be repaired or replaced is an asset in its favor; but the claim of high clearance is open to question. Under certain conditions of operation unprotected side chains constantly plow through a bed of mud, and although they can get through it is at the cost of their chains.

DEFECTS REVEALED BY WAR SERVICE.

It is not an easy matter to generalize on defects revealed by war service. There is not a make of truck that has not developed some weak point of minor or major importance. To cite all these would tend to give the impression that automobile trucks are a hotbed of trouble, whereas few of the defects are applicable to more than one or two makes. For instance, one American worm-driven truck cracked its axle housings; this was a case of faulty design, and was a particular and not a general defect. A light American truck literally ate up differential drive shafts; this was traced to poor material. A French chain-drive truck warped its differential casing under heavy braking stresses. Another had cast timing gears mounted on bearings of insufficient size. Vibration ensued and the gears were reduced to what the mechanics termed "marmalade." A more general complaint was the breakage of canvas and leather universal joints, it being not uncommon to see drive shafts flung across the road during heavy pulling in sand and mud.

Spring troubles were fairly general, but in only a few makes did the breakage of a front spring entail the smashing of the crank chamber. In these makes when the frame dropped the basechamber came in contact with the axle. Also, spring failures were almost invariably confined to the front, it being rare for a rear spring to break, even on trucks and cars known to be of poor quality. On trucks this may be attributed to the narrowness of the front wheels; these would drop into small holes over which the rear tires would ride safely, thus putting additional stresses on the front. Few if any trucks on war service had sufficiently heavy front springs. The generally adopted method of attaching the springs to the axle cannot be considered safe. Not one driver in a hundred thinks it necessary to give any attention to his spring clips, yet these have a habit of working loose, and in many cases when an axle has shifted it is practically impossible to steer the vehicle. Frequently the complete breakage of a front spring is to be preferred to the loss of nuts or the breakage of clips.

Radiators were a general source of trouble, many a good engine being burned out by reason of small diameter tubes or by brackish water. The honeycomb radiator is not suitable for army truck service. The large diameter vertical-tube type is most successful, and is adopted whenever replacements become necessary. It has been found to give good service even when used on trucks that originally had a honeycomb cooler. Incidentally, it is not safe in the war zone to judge the make of a truck by its radiator. Another good type is the circular tube radiator with a centrifugal fan, as used on the Paris omnibus type of chassis.

* Paper to be presented at Semi-Annual Meeting of Automobile Engineers.

†European correspondent *Class Journal*.

REQUIREMENTS IN ENGINE DESIGN.

Considering a 3½-ton truck as the most suitable type (and of this all who have had experience in the war zone are in agreement) the engine should be a 4-cylinder L-head of about 450 cubic inch piston displacement. It has already been stated that the under-the-seat position is not suitable except for special service where a maximum body space is required. The underpan is an abomination on an army truck. The basechamber should be easily removable, although unfortunately this does not necessarily follow when there is no mudpan. The connecting-rod bearings should be detachable, so that it is possible to change them, in case of necessity, without taking the engine out of the frame. A governor is a desirable equipment.

War service has tended to prove the superiority of pump circulation over thermo-syphon. As a general rule trucks tend to overheat when operating in convoy formation on crowded roads. This condition, only occasionally met with on civilian service, is common on certain portions of the front, and should be provided for. There are few trucks on which sufficient attention is paid to draining off all the water from radiator, pump and jackets. This is a detail when trucks are housed in a heated garage; it is an important feature when automobiles remain constantly in the open air, with the possibility that the engines may have to be cranked, to meet an urgent call at 2 or 3 o'clock in the morning.

No man who has had to start an engine at daybreak on a frosty morning, with the knowledge that delay meant disaster, is inclined to treat this matter lightly. It is common practice for drivers to make straw mats to fit the hood and the radiator, and to use these as heat retainers whenever the truck has to stand idle for a few hours. An additional precaution is to disconnect the gasoline line, empty the float chamber of the carbureter, and leave one of the kerosene side lamps burning under the hood. The manufacturer might help in this direction by making a tightly fitting hood with louvres that could be opened or closed at will, by supplying a heat retaining radiator cover and also providing a safety lamp capable of maintaining a certain amount of heat under the hood when the truck is left standing in the open all night. An adjustable air-shutter on the carbureter is a valuable fitment. It is important, too, that the engine should develop something like its full power within a few minutes of starting. In the early days of the war, before men had learned to take precautions, the writer has known convoys to be held up for 3 or 4 hours owing to starting difficulties. A delay of this nature is sometimes fatal.

Mechanical starters are not necessary on army trucks. In the few cases where these have been fitted the batteries have generally been requisitioned to light some dug-out or office. As there are always two drivers on army trucks, it is hardly necessary to relieve the spare man of the only real work he has to perform.

RADIATOR GUARDS FOR ALL TRUCKS.

All army trucks should have radiator guards attached, not to the radiator itself, but to the frame members. The design should be such as not to interfere with free operation of the starting crank. Some guards have been supplied that certainly protected the radiator but caused a bit of finger to be left behind every time the crank had to be swung. The guard should be so designed, too, that it will not allow the overhanging rear of the body to pass above it. In some cases it has been found advisable to fit a transverse bumper with coil springs at the rear of the trucks, this bumper coming in contact with the center of the radiator guard in case of a collision. It must be remembered that many of the drivers have had little road experience. The traffic is much more dense than is generally imagined. During the height of the Verdun battle there was a 90-mile circuit over which trucks passed day and night, for a period of several weeks, at average intervals of 20 seconds between each vehicle. This means that at times traffic was as dense as it is on lower Broadway during the rush hours.

It has been noticed by officers in charge of army repair depots that engines with the old-fashioned splash system of lubrication are generally better preserved than those with pressure feed of oil to all bearings. On war service the lubricating oil is apt to remain in service longer than is desirable, and the impurities deposited in the oil are picked up by the pump and forced into the bearings. The remedy seems to be, not a return to splash, but a pressure or circulating system so designed that the dirt will deposit away from the pump. It is really not necessary that the pump should be in the lowest portion of the basechamber. The basechamber can be designed so that the lowest portion is merely a trap for impurities, and this can be done without any danger of the pump being accidentally deprived of oil. Whatever the system it ought to be an easy matter to dismount the pump and to drain the basechamber of every drop of lubricant. This presupposes the absence of a mudpan. Several American trucks have suffered materially and in reputation by the absence of a suitable oil. Pressure feed being common in Europe, a heavy oil is generally employed, and this has been used with disastrous results in engines requiring a light bodied oil. The only remedy appears to be for manufacturers to clearly indicate the type of oil to be used on their engines.

GASOLINE ONLY ARMY FUEL.

So far as the Allied armies are concerned, there has been no necessity to use alternative fuels such as benzol, alcohol and kerosene, although it was a pre-war specification in France that all automobile trucks should operate on benzol and on a 50-per-cent mixture of benzol and alcohol. Benzol and alcohol have been monopolized for making explosives, and gasoline has been the only army fuel in use. It is certain, however, that the benzol requirement will be insisted on after the war, and in all probability alcohol will be a widely used fuel.

The best place for the fuel tank is on the dash. Pressure tanks at the rear are inconvenient and dangerous. The filler should be of sufficient size to allow a man to pass his hand inside the tank, and there should be easy provision for draining the tank. Drivers in the war zone invariably carry a reserve supply of gasoline, this being done because of the feeling of security it imparts rather than because of any urgent necessity for its presence. Suitable provision has not been made, particularly on French and American trucks, for the carrying of this reserve supply. Thus drivers have had to fix up as best they can a storage place for a 12-gallon can of gasoline.

Ignition by high-tension magneto has proved all that could be desired for war service, no need having been shown for a second system, either as a reserve or for ease in starting. The only general trouble has been the swelling of the fiber and condensation on the spark-plug points, this being due to the excess of moisture in the atmosphere of northern France. The French military authorities have insisted on the standardization of magneto bases and couplings, and also on all magnetos turning right-handed. The intention, of course, was to make all magnetos interchangeable throughout the army, and although this result has not been obtained, owing to the influx of foreign machines, the system has been good so far as it has been possible to apply it.

There is an amazing lack of uniformity in the steering lock and the turning radius of army trucks. This is most disadvantageous when convoys are composed of different makes of trucks, for while one vehicle can make a turn easily the one following may be unable to do so. The disadvantage is also felt where makes are grouped, for one convoy may negotiate a difficult road with ease while the next will be stopped. In some makes of trucks the short turning radius is only an illusion, for owing to the radiator extension in front of the axle it is only possible to turn within the given radius if the road is entirely free. In other cases the radiator is so high that it is impossible for the driver to see directly ahead and take full advantage of his lock. This matter is important, for when a road is under fire the greater the time spent in making a turn the greater the chance of being hit by a shell.

Only the southeastern end of the present battle line is in a mountainous district. Thus brakes have not been put to a severe test. Generally there is much room for improvement in the matter of brake adjustment. Several cases have been noted of brake rods so close to the road or to the road wheels that they have been bent by a board lying in the road and thrown up at an acute angle as the wheels passed over it. Brake rods should be regarded as organs needing protection and placed in such a position that they are not likely to be damaged by obstacles on the road. Not many American trucks are fitted with a sprag, although this is a valuable accessory on military trucks working in convoy formation in hilly country. Picture a closely packed convoy on a greasy hill, trucks without sprags, and a green driver in the center of the column who misses his gears and fails to use his brakes in time.

Four-speed gearboxes are now insisted on by the French military authorities and are found to be indispensable for active service. First speed should be equivalent to 2 m. p. h. with the engine running at its normal speed (1,000 to 1,200 r. p. m.). One type of gearbox that has proved satisfactory under war service is the Damaizin patent constant mesh gears. This gearset was fitted to the Paris bus chassis and its use has been extended to other makes. It is impossible for a driver to muddle his gears, no matter how ignorant he may be of the elementary methods of changing. No experiments have been made with trucks without a differential, but a differential lock, capable of being operated from the driver's seat, if possible, is an absolute necessity under many conditions of active service. The only reproach brought against one of the best American trucks on the French front is the absence of this lock.

OPERATION OFF MADE ROADS.

This naturally leads to the question of operation away from made roads. The greatest objection brought against the automobile truck is the rapid fall of its efficiency as road surfaces deteriorate. The touring car, the ordinary commercial truck applied to war service and the various types of 4-wheel drive and purely military vehicles are all, in varying degrees, open to improvement in this respect. The general rule is that convoys should keep to made roads and not attempt to operate across country. Officers using touring cars are specifically forbidden to order their drivers to go across country. While this general rule is observed, there are frequent circumstances where the made road practically ceases to be a road, or where the only means to safety lies in a dash across country. The final distribution of food and ammunition under really difficult circumstances is still effected by horse teams or by men. A 2-wheel cart with a ½-ton load will get over a road where a 3-ton vehicle, whether drawn by horses or propelled by a gasoline engine, would be in difficulties. If the light cart is hit by a shell the wreckage is easily cleared away and the procession continues; but a heavy truck disabled on a narrow dirt road stops all further traffic.

The most common expedient to render a truck fit to travel away from hard road surfaces is to fit chains to the wheels. These, however, have been far from giving general satisfaction. The circumferential chain, lodged in the space between the dual tires, has not been a great success, for the available space is too narrow to allow of a heavy chain being fitted, and breakages are frequent. The same objection applies to the type consisting of a circumferential chain placed between the dual bands, with transverse ribs at regular intervals having one surface in contact with the tread of the tire and the opposite face in contact with the road surface. The chain uniting these ribs has always proved too weak.

Short lengths of chain, hooking from the outer to the inner face of the rim, across the tire, fitted among others to the Pierce-Arrow trucks, are fairly satisfactory. The lengths being independent, the breakage of any one does not affect the efficiency of the device. Experiments were made with the same trucks with a caterpillar attachment secured to a flange bolted to the wheel felloe. This device was quite unsatisfactory. After a truck became bogged it was impossible to apply the attachment, and if used over a made road it broke the chains or bent the steel shoes in such a way that they could not be used a second time. In the case of some of these trucks, carrying a heavy load of armor and an anti-aircraft gun, it was found that if the ordinary chains would not take them through, nothing else would. Thus these chains were always kept on when operating away from the roads.

It is surprising, however, how soon a set of chains will be eaten up if used over a hard macadam road or a granite surface. A few seconds are sufficient to reduce a set of chains to individual links and portions of links under certain road conditions. Thus the necessity arises for a quickly detachable device, so that it can be taken off immediately a hard road surface is encountered. It should also be pointed out that the ordinary chain devices are not applicable to chain-driven trucks, the clearance generally being insufficient between the road wheel and the pinion to allow a chain to be attached. It is not necessary to describe what happens when an antiskid chain breaks away and mixes itself with one of the driving chains.

A device adopted as the result of practical experience in the field consists of an endless chain passing round the road wheel (fitted with dual tires) and around a loose pulley some distance back of the road wheel. A spring-controlled bell-crank arrangement operates on the pulley and maintains a sufficient tension on the chain. On greasy roads and mud-coated granite surfaces this was a most effective non-skid device and one that gave little trouble through breakage. It was found to be useless, however, on soft earth. Under these conditions the chain refused to revolve with the driving wheel and the whole thing became embedded.

The problem of securing traction has not been confined to rear-wheel drive trucks. Four-wheel drivers have had to face the same difficulties, although, of course, in a different degree. The most difficult feature has been to find a device that would prove satisfactory under all circumstances.

(*To be continued.*)

Elevation of the Aurora Borealis

A RECENT expedition to northern Norway was able, by means of simultaneous photography, taken from two stations, to make 2,500 observations on the height of the aurora borealis. It was found that by far the greater number of displays took place at an elevation of about sixty to sixty-five miles. A few were observed as low as fifty-three miles, and as high as eighty-five miles.

Shadow Pictures By Parallel Rays

Negatives Produced Direct, Without a Lens

A German professor, Dr. Paul Lindner, has invented a method by which shadow pictures of both animate and inanimate objects can be made, which give outline and structure with quite startling fidelity and clearness. These photographs, or "bright shadow pictures" as they were cleverly dubbed by one of the inventor's colleagues, are taken by parallel rays of light, or by instantaneous exposure, 1/100 of a second sufficing.

We quote from an account furnished by Prof. Lindner to *Die Umschau,* to which we are also indebted for the pictures shown, which are quite remarkable both for fidelity and for beauty.

" I had occasion one day to make a micro-photograph of the minute animalcules thickly populating a specimen of fermenting gentian mash sent me by my colleague Prof. Henneberg from the Engadine. This was soon done, since I have acquired some skill in taking instantaneous photographs of highly enlarged objects. But the animalcules soon presented a new problem. They began to climb the walls of the Erlenmeyer flask in which they were placed, forming the most beautiful network in their continual serpentine motions. The rapid alteration of form of the network on the curved walls of the flask made it seem inadvisable to attempt to get an ordinary photographic negative with the camera, since such a one could not fail to lack sharpness of definition.

"Then I bethought myself of a copying process which I had repeatedly employed in getting prints of my finger cultures in so-called 'roll-cylinders.' This process consists in wrapping the copy-paper closely around the cylinder and then exposing it to the light of the ground glass pane in the dark-room. But this light would have been too feeble for an instantaneous negative of the swiftly moving amimalcules. I therefore placed the Erlenmeyer flask in the rays of an arc light, with an exposure of 1/90 of a second. I had previously taken care to cut off all side-lights. The very first picture was entirely successful, showing with great clearness over the whole surface of the gas-light paper (9 x 12 centimeters) the network figures and the separate wandering cells within their meshes. This clearness was evidently the result of the fact that the rays were parallel and not crossed by rays from side lights.

"I now went a step further and replaced the instantaneous shutter by a large pasteboard disk, with an adjustable slit; furthermore, I insured by the use of mirrors that the light should fall always from above. These arrangements made it easy for me to handle the process alone. The first thing I did was to plunder my old herbaria and copy all the specimens of delicate structure —grasses, etc. I then undertook fresh plants, which I placed in their natural condition on the gas-light paper, i. e., without flattening them. I next proceeded to subjects possessing motion, such as flies, spiders, ants, and living fresh water animals, which were placed in a thin layer of water in a low glass dish with as even a bottom as possible. Finally I took for subjects plate cultures of yeast, bacteria, or mildew."

Dr. Lindner remarks that the most striking characteristic of these "bright shadow" pictures was the vividness of the appeal made to the eye by outline and structure. He explains this by observing that in the actual object the attention is involuntarily attracted by color and superficial structure, so that we fail to perceive outline and essential structure. For this reason we are blind to the beauty and harmony of design inherent in many of the commonest objects which daily greet our unheeding eyes. An ordinary chicken feather, for instance, like that shown in Fig. 8, is quite exquisite in its delicacy of outline.

It is quite obvious that such photographs as these may be very stimulating and helpful to artists, decorators, and students of design. The author quotes a remark once made to him by the famous German painter Lenbach, that he preferred trees in the winter time, before their foliage had obscured the development and arrangement of bough and branch. Lindner remarks too on the clear-cut beauty of the patterned foliage thrown on the walks of cities by overhead electric lights. These shadows are thus beautiful, surpassing those made by the sun, precisely because they are cast by nearly parallel rays. Similar clearness is attained by sunlight only on cloudless days, and in places where no bright reflex light is thrown by white walls, etc. This explains why these shadow-pictures have a marked advantage as to clearness over those taken by the camera; furthermore, they escape the imperfections due to the unavoidable defects of glass lenses.

In taking transparent objects, however, such as crystals, cut stones, portions of plants which have been made transparent (see Fig. 6), by this method there may be some divergence of the rays.

"In using this method for getting pictures of green fluorescing bacteria, the photograph betrays the presence of the fluorescing substance surrounding the colony

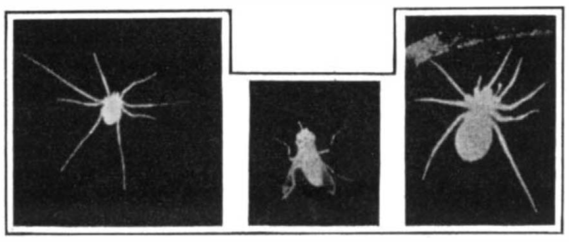
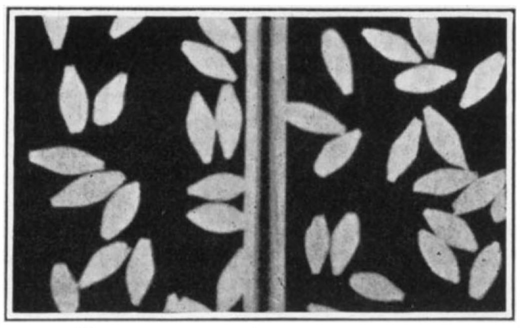
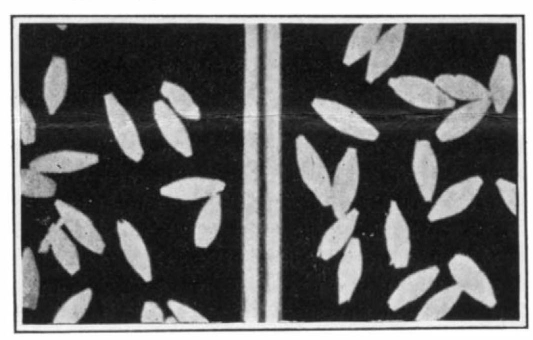


Fig. 1. Fig. 2. Fig. 3.

Fig. 1.—Live treebark spider, confined in glass dish and taken during motion by exposure of 1/100 of a second.
Fig. 2.—Housefly taken in 1/100 of a second.
Fig. 3.—Spider taken while moving—exposure 1/100 of a second.



Sieve *a.* Sieve *b.*



Sieve *c.* Sieve *d.*

Fig. 4.—Application of shadow pictures to testing size of grains previously sorted by sieves.
1/100 of a second. Sydow barley. Sieves *a, b, c, d.*

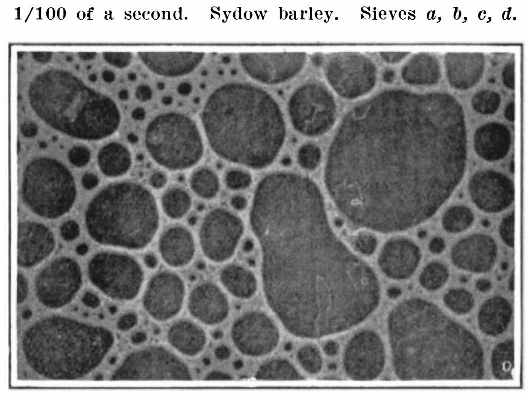


Fig. 5.—Beer-foam, 8 seconds old, between two glass plates about 1 millimeter apart.
1/100 of a second.

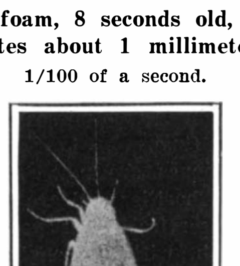


Fig. 6.—Cockroach.

when the mere eye had perceived nothing. When one wishes to obtain the finer details in transparent or translucent objects, of course the object must be placed as near as possible to the photographic surface. This is especially true in copying colored glass pictures on autochrome plates, in which case these must be so placed under the original plate that the glass layer of the autochrome plate forms a rather thick layer between. But the parallel rays assist in obtaining sufficient sharpness, where the ground glass or a cloudy sky would mean failure.

"When we enlarge the original shadow picture of the chicken feather 40–50 times by means of the microscope, structures are revealed which are completely hidden from the naked eye. Peculiarly instructive, too, was the study of the microscopic enlargement of shadow pictures of thin sections of stones. Thus a great number of parallel lines were often shown in a clear surface of the section or 'slice,' corresponding to the cleavage surfaces of the crystal. Therefore my 'bright shadow pictures' should be looked at under a lens or in a microscope. For colored shadow pictures the required plate material (Lumière autochrome plates) is unfortunately non-obtainable during the war, and we must confine ourselves to black and white."

Prof. Lindner observes that our reproduction technique is not yet perfect enough to give on the printed paper the full beauty of the original shadow pictures.

Feeding the Firing Line

By Walter S. Hiatt*

As much science is employed in putting food into a soldier's mouth as in putting bullets into his opponent's skin. There is more method in supplying food to cavalry and wagon horses, gasoline to army automobiles, shells to cannon, medical supplies to hospitals or material to the engineering corps, than there is madness in the war itself.

The task of carrying supplies to an army of 4,000,000 men, concentrated, as in France, on a line 600 miles long by 20 deep is one of the most complicated of the war. It does not begin to give a conception of the vast transportation problems involved to say that daily 25,000 tons of rations must be forwarded to the soldiers, that 1,000,000 quarts—a veritable river—of wine must reach them, that 75 tons of lead must be shipped for each German killed or wounded, or that the cost of war material forwarded each day is $10,000,000. One railroad alone furnishes more than 3,500 cars a day for army transportation purposes; 100,000 automobiles and 600,000 wagons are required to distribute the shipments at the front.

When I received an invitation from one of the members of the general staff of the Fourth Bureau of the War Department (the bureau in charge of railroad transportation) to visit one of the great storehouses which assembles and redistributes supplies for the front, I accepted the invitation gladly. I expected, nevertheless, to meet only with the prosaic freight details that may be seen at any big railway center. It seemed like studying over again the machinery of supplying some big city of civilians.

My attitude was much like that of a civilian official in charge of the supplying of artillery for the front. Officers at the front kept calling so insistently for more and more cannon, that finally one day last summer he made a trip to discover why the steel plants were not turning them out fast enough, by the thousands, just like so many pins, instead of a few a month. When he reached a certain plant, he was shown a huge block of steel about the size of a small railway station. "What is that for?" he asked. "Why, that's the beginning of a 420 mm. cannon," answered the proud manufacturer.

"Oh, but I never thought it took so much steel as that," said the civilian. A little further he saw another block of steel with a hole punched in it. "And what is that?" he asked. "That's the second stage of the cannon," was the reply. "Oh, oh, oh!" exclaimed the civilian, eyes bulging, "I never knew you had to punch holes like that." When he quit the plant he was quite satisfied that the business of making cannon took lots of time.

As the staff officer and I rode out in an army automobile toward the central distributing plant, I ventured to express myself. He smiled and handed me a 200-page book, printed in small type, containing the old army regulations for handling commissary supplies. "That's but one branch of the subject," he said, "and there's a whole library filled with books on it. However, this war has put them all out of date."

For a while just after the war began the immense armies and the problems resulting therefrom compelled the officers to resort to methods established 250 years ago by Louvois, minister of Louis XIV, at a time when

*Special European Correspondent of the *Railway Age Gazette.*

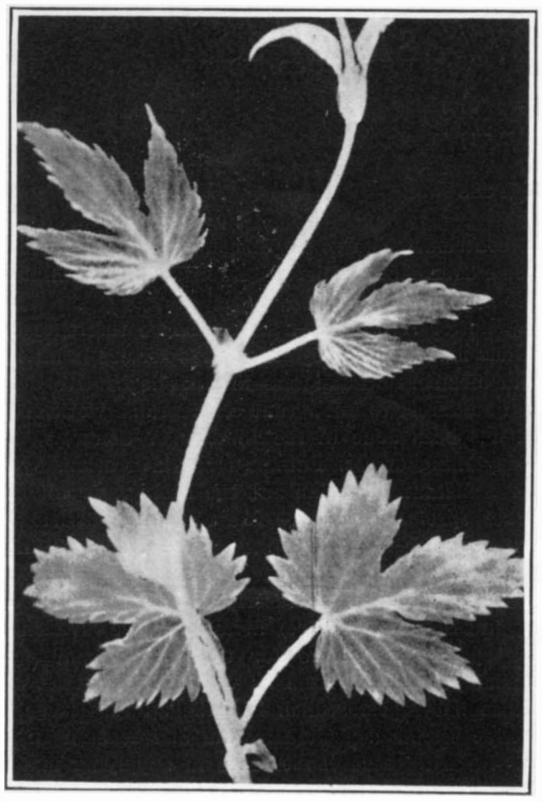


Fig. 7.—Young hop-vine.

armies had hardly ceased being mere mobs of men, living from hand to mouth, and destroying or stealing for what each individual could make out of it. For a time they followed the methods of Napoleon, quartering soldiers on civilians, making levies on cities for supplies, or in short, living on the country where they happened to be.

It is true that there were before the war ten railway centers for as many army warehouses, containing reserve supplies. These were distributed in different parts of France so that as many different sections of the country as possible could be drawn upon without disturbing, in theory, the source of supply abnormally. There were also 91 bread factories, 58 parks for grazing livestock, and 32 concentration storehouses, containing in all 767,000,000 rations.

The war has broadened this system quite considerably. Now, all supplies, whether obtained by the commissary department or other departments of the minister of war, or by requisition commissions in the French colonies or in any of the 78 uninvaded departments of France, are directed to some 20 *stations-magasins*. These are situated about 50 or 100 miles from the front at points where there are extensive freight yards. They in turn send supplies by railway to the *gares regulatrice* (regulating stations) whence after the cars are classified, they are sent on to the *gares de ravitaillement*, possibly from 5 to 15 miles from the front. Supplies are carried from there on in army wagons, automobile trucks, or on narrow gage railways over which the cars are moved by noiseless Decauville engines.

The *stations-magasins* or central supply stations are, of course, at strategic points reached with facility from important seaports and other cities. They are divided into four sections, one for the commissary, one for the artillery, one for the engineering corps and the fourth for the hospital service. Each of the score of stations is required to forward daily supplies for a certain number of men, possibly 50,000 or 100,000 and in some cases more. To be on the safe side, and for fear of possible freight congestion, the *gares de ravitaillement* have on hand supplies sufficient for 10 days.

The commissaire militaire at the *station-magasin* has to forward daily from 1 to 3 trains of supplies (40 cars usually being necessary to supply an army corps for 1 day) to each *gare regulatrice*. The officer in charge of the latter classifies the cars and forwards them to the *gares de ravitaillement*, the location of which varies according to the movements of the army and at this point, as noted above, the supplies are unloaded and held until forwarded to the firing line.

The most important if not the most picturesque of the various centers is the *station-magasin*. The regulating stations merely classify cars and pass them on while at the last stations the quantity of supplies discharged at any one point is relatively small, though the operation may be done to the tune of enemy artillery shells or aeroplane bombs.

Arrived at the railway depot of X, in peace times an important railway center, we were met by the commandant who is the *commissaire militaire* both of the depot and the *station-magasin*. In explaining the function of the *station-magasin*, he compared it to a reservoir at a mountain base, receiving the water as it came helter-skelter down the mountain and guiding it in a regular stream to the insatiable desert beyond.

By way of putting his visitor at ease, the commandant remarked laughingly: "The *station-magasin* I am going to show you merely represents what we do. We have here in the surrounding country hundreds of head of sheep and cattle and a veritable little Chicago stock yard for slaughtering our pigs and hogs, making them up into sausages and other meats for the soldiers. This slaughter house is none other than the Chateau L——, once the French country house of King Leopold of Belgium."

"I hope you don't confuse cats and dogs with your hogs," I suggested, "as our American slaughter houses were once accused of doing."

"No, but we ship your canned meats to the soldiers just the same. They call the tins 'boxes of monkeys.'"

In company with the Commissaire Militaire, Commandant D——, and Colonel M——, of the Intendance, we visited the transportation city. The latter has a personnel of 1,800 soldiers, made up of railroad men, bakers, carpenters, men of the engineering corps, etc.

As Colonel M—— told the story of the city which he had built, I was reminded of the Western cities that used to grow up over night around railroad terminals out of the trampled grass of the prairie. The colonel explained that he had been assigned to his work May 10 last, when the growing size of the armies put in the field made it impossible for the ten original supply stations to handle the job. "When I came here," he said, "I was given a field of oats and ordered to begin supplying 100,000 men every day, with instructions to take over later a few side lines like feeding 35,000 horses, etc. Our first 100,000 rations went forward June 18, and we have not missed a day since. My tracks and other facilities cost but $100,000."

How had the work been done? I looked in vain for the oat field. The space he indicated with a sweep of his hand, possibly 30 acres, adjoining the permanent yards of the Orleans railway, was covered over with tracks and buildings, some 40 in number. The buildings were erected after the solid French fashion, covered with red tiled roofs, fit to stand for a quarter of a century. On their outer fringe stood the semi-temporary quarters of the soldiers.

It is truly said that wherever the French go, they build everlasting roads. As we went toward the city, we traveled over a graveled road, newly made, on which the soldiers were still working, laying solid stone foundations against the mud and rain of winter. When the war is over the farmer who owns that oat field will have his work cut out for him tearing up that road.

As we walked into the city with its streets, its population of busy soldier workers, in their sky-blue uniforms, the colonel pointed out his water hydrants and told how he drained the rain into a large central cistern from which he could obtain a sufficient supply of water in case of fire set by some spy, an aeroplane bomb or by a locomotive spark.

The pride of the city seemed to me to be the wonderful bakeries whose products are loaded into dozens of straw-lined cars each afternoon and sent to the front. These bakeries turn American flour into the sweet-smelling 3-pound loaves of bread that really form the staff of life of the French soldier. That is why the bread train is the one he waits for most patiently, and expectantly. There are in all 24 buildings devoted to making bread, divided into 3 series of 8 each, one series for the storing of the flour, a second for the baking of the bread, and a third for storing it previous to loading.

A curious detail of the bakeries lies in the fact that the heat is derived from wood burned in a slow, smothered fire, so that some charcoal is obtained, a ton a day, and this charcoal shipped to the cooks in the trenches. In order to get this invaluable smokeless fuel, the locomotives at the front also occasionally burn wood and manufacture charcoal for the trench cooks.

An interesting detail of the transport city was the method of shipping the wine to the front. It is received in special tank cars, not unlike an American oil tank car, run into small barrels of 200 litres each, and these reshipped in freight cars. The coffee, too, is received here in bulk, roasted in a building built for that purpose, and then reshipped in small sack lots. "We really run a sort of wholesale grocery," remarked the colonel.

There are 8 tracks, each 1,600 feet in length, laid to care for the trains that are made up daily. Bulky supplies, hay for the horses, bread for the men, shells for the cannon, whatnot, are carefully put into the same car, while the small groceries, the *petits vivres*, the meats, coffee, sugar, tobacco, salt, pipes, cheese, are put together perhaps in the same car. This distribution is made to prevent confusion in deliveries and disputes as to quantities.

When the cars are duly labelled, bills of lading made for their contents, the train made up, soldiers and officers from the various departments represented board the train, and it pulls out to the main track with the right of way.

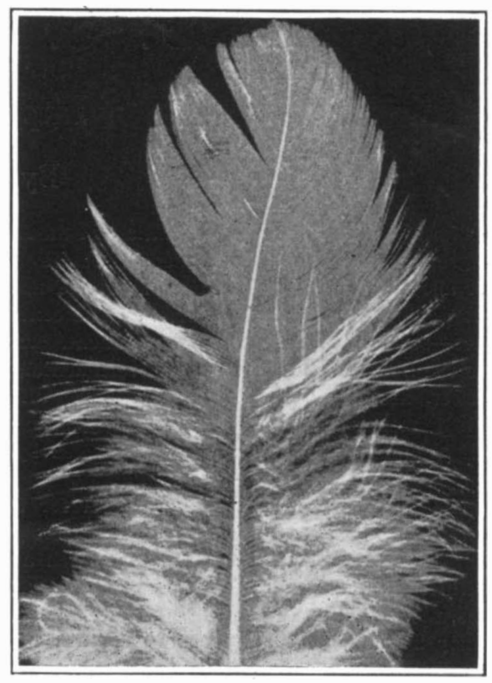


Fig. 8.—Chicken feather.

When it reaches the *gare regulatrice*, where dozens of other such trains are centerings, the trains are ordered to such and such a destination, perhaps first broken up and part of their load sent one way, part another, according to the needs of the day.

As a train from the *gare regulatrice* reaches the third and last stage of its journey, it drops off a car of supplies here, another there, as the orders run. If a battle is raging at the front, the engineer may receive orders to wait until night before venturing along the danger zone, or, if the need is pressing, he may brave the shells and proceed.

Shooting Soot From Chimneys

THE big chimneys of industrial plants often become partially obstructed by accumulations of soot, which are expensive to remove by ordinary methods. A new and economical scheme has been found for doing this work, and that is to shake the soot down by the shock of an explosion. A simple and effective way to do this is to make a small cannon by drilling a hole one and three-quarters inches in diameter and ten inches deep in a piece of four-inch shafting about fifteen inches long. This gun may be mounted vertically on a plate of iron, and is fired by a fuse hole drilled in one side of the shaft to intersect the bottom of the bore. The gun is charged with blasting powder up to about two inches of the muzzle, and the remaining space is filled with dry clay and tamped. The gun is placed for firing on the flue floor at the bottom of the stack, and three or four shots will ordinarily shake down the soot, depending on the condition of the stack. A gun of the size given, and with the above charge, is sufficient for a stack 100 feet high, but a longer gun, with a somewhat increased charge, would be necessary for a taller stack. This method of cleaning chimneys is said to have been used for several years with satisfaction, and without injury to the stack. It should be noted that the gun directs the air disturbance upward, while if a loose cartridge were fired it would be likely to blow out the base of the stack.

Water Pressure

A CUBIC FOOT of sea water weighs 64 pounds. Each cubic foot may be regarded as standing on a base of 1 square foot. Therefore, the pressure at the base of a cubic foot of sea water is 64 pounds per square foot. Now, a cubic foot of water, having a base of 1 square foot, must be 1 foot high. The pressure at its base (64 pounds per square foot) is, therefore, the same as that pressure which would be encountered at 1 foot below sea level.

Now, 144 square inches make 1 square foot. A vertical column of water having a sectional area of 1 square inch would, therefore, weigh 1/144 as much as a column equally high but having a sectional area of 1 square foot. Since the pressure per square foot is 64 pounds, the pressure per square inch is 1/144 of 64 pounds $= 64/144 = 4/9 = 0.44$ pounds per square inch.

At 2 feet below sea level, or double the depth, double the height and weight of water stands on each square inch, therefore, the pressure is double $= 2 \times 0.44 = 0.88$ pounds per square inch. Each extra foot of depth adds an extra pressure of 0.44 pound per square inch. To find the pressure at any depth multiply the depth in feet by 0.44 pound per square inch.—*The Steamship.*

The U. S. Government Libraries at Washington*

Important Institutions of Great Value to the Nation

By H. H. B. Meyer, Chief Bibliographer Library of Congress

The Library of Congress.—The relations of the Library of Congress to the other government libraries (which number about 63 out of a total of 137) are of necessity very close, since they are all under the same controlling influence—service to the Federal government. Its relations to the libraries in the city not governmental, while less direct, are hardly less intimate. They all draw from its immense reservoir, and their acquisitions and even their management are largely influenced by their proximity to the Library of Congress.

Founded by the "Act to make provision for the removal and accommodation of the Government of the United States" approved April 24, 1800, which act carried with it an appropriation of $5,000 for the purchase of books, the collection remained in a protoplasmic state for nearly 2 years, without form and doubtless rapidly becoming void. The members apparently helped themselves to the books with the usual result. It was recognized soon that some organization must be effected to take care of the collection. This was done by the act of January 26, 1802, and on the 29th of the same month John Beckley was appointed first Librarian of Congress. During the first sixty years of its career the growth of the library was gradual. Thrice it suffered from fire. After the destruction of the Capitol by the British troops in 1814 it acquired in 1815 the interesting and valuable collection of Thomas Jefferson, but unfortunately two-thirds of this was destroyed in the fire of 1851. These losses, as far as numbers were concerned, were made good almost immediately, so that it is fair to say that the average growth during these 60 years was about 1,000 volumes per year, and in 1862 there were something over 60,000 volumes in the collection.

With the appointment of Ainsworth R. Spofford, December 31st, 1864, the growth rapidly increased so that when the library was transferred to the new building in 1897 it numbered 787,715 volumes and pamphlets, an average increase of 22,000 yearly. When Dr. Herbert Putnam, the present Librarian of Congress, was appointed in 1899 the collection was still considerably below a million. Its growth has since been at an average of about 100,000 volumes and pamphlets per year and now the library contains about 2,500,000, having become the largest library in the western hemisphere and the third largest in the world, surpassed only by the Bibliothèque Nationale (4,000,000 volumes) and the British Museum (3,000,000 volumes). In an enumeration of the resources of the Library of Congress there should be added to the 2,500,000 books and pamphlets, the manuscript collection of which an exact numerical statement is not feasible, but which contains several hundred thousand pieces; maps 150,000, music 700,000 pieces, and prints 400,000 pieces. Those who are familiar with the national libraries of foreign countries frequently remark that the Library of Congress is more truly a national library than any other library in the world in the extent and variety of the functions it performs, and the service it renders to libraries and to citizens throughout the country.

Its organization—administration.—A brief description of the organization of the Library of Congress will best serve as an introduction to an account of its activities. At the head of the institution is the Librarian of Congress, Dr. Herbert Putnam. In immediate contact with him are the Chief Assistant Librarian, the Office of the Secretary, and the Chief Clerk's Office. These constitute the administrative offices. The Secretary's Office has charge of all the correspondence with outside institutions and individuals, and is the official means of communication between the library and the rest of the world. The Chief Clerk's Office is the center of communication within the library, has charge of the stationery and supplies, keeps the accounts of the library and all service records, including appointments, promotions, resignations, etc. With him is also located the photographic apparatus for making exact copies of manuscript or valuable printed matter for use outside of the building. In direct touch with the administrative offices and in fact all the divisions of the library is the Mail and Delivery Division, which receives all material sent to the library by post, express, messenger, etc., and then distributes it to the several divisions. Official correspondence is sent to the Secretary's Office: publications intended for copyright entry to the Copyright Office; documents to the Document division, periodicals to the Periodical division, all other acquisitions to the Order division, and books, pamphlets, etc., sent back by members of Congress, government bureaus, and officials to whom they had been lent for official use are sent to the Reading Room to be returned to the shelves.

Copyright.—The Copyright Office is somewhat apart from the other divisions of the library. It makes the necessary records for all copyright claims and after stamping the publications sent in for copyright, so as to identify them with the copyright entries, forwards them to the Order division for addition to the library collection. In this office every safeguard is used to insure a complete and indubitable record, because at any time the entry may be subjected to a challenge in court of law.

Order division.—The Order division takes cognizance of all acquisitions, with two exceptions, documents go to the Document division and periodicals to the Periodical division direct. Documents and periodicals not current, which have been purchased, however, pass through the Order division to be paid for. The sources of the publications received by the Library of Congress are the copyright deposits, government documents, including foreign, United States, State, and municipal, purchases, gifts, exchanges, transfers from other government libraries of material they do not need, and deposits from the Smithsonian Institution. The Order division transacts all business connected with these acquisitions and in addition has a general supervision of the production and distribution of Library of Congress publications which enter largely into our exchange transactions.

Periodicals.—The Periodical division besides receiving, checking and preparing the periodicals for binding, is also a service division. In its reading room unbound periodicals and newspapers are used. When bound the periodicals pass into the custody of the Superintendent of the Reading Room as part of the main collection of books.

Documents.—The Document division is mainly a forwarding division, receiving, checking and making ready for binding and cataloguing public documents of all kinds. It also prepares the monthly list of State documents sent regularly to all State officials as an acknowledgment of material sent to the Library of Congress, and recognized as a most valuable index to a very important group of publications.

Cataloguing.—The Catalogue division is the chief forwarding division of the library. It not only catalogues the books but in it are centered their classification, shelf listing and labelling.

Card distribution.—The Card Distribution division is like the Copyright Office, somewhat apart from the rest of the library, but a most important division to other libraries. It is the selling agency for the Library of Congress cards. It receives and fills all orders for cards, packs them for shipment and keeps the necessary accounts.

The remaining divisions and subdivisions of the library are properly designated as service divisions; two, the Reading Room and the Bibliography division are of a general character while the others are devoted to some special constituency or some special subject.

Reading Room.—The Reading Room has charge of all the books and pamphlets in the library excepting those consigned to special divisions. It has complete charge of the circulation which is practically limited to the government service, and looks after the interlibrary loans. The Reading Room and Periodical division are the divisions which render the most direct service to the public. Both are free to all readers and are open daily from 9 A. M. to 10 P. M.

Bibliography division.—The Bibliography division is in a measure a reference division or bureau of information. It serves to a certain extent as a key to the resources of the library. Its contact with the public is limited to those requiring bibliographical aid not satisfied by the printed material available in the Reading Room. All miscellaneous questions not taken care of by the special divisions are submitted to it. Its replies usually take the form of directions to sources of information and not the information itself, excepting where the inquiry comes from some locality devoid of library facilities and the information desired can be comprised in a brief memorandum. The Bibliography division has in constant preparation reference lists on topics of present day interest. These are first put in typewritten form and lent freely to libraries all over the country. If the interest in the subject warrants it the list is printed either as a separate publication in the well known series of Library of Congress reference lists or as a contribution to some journal—"Special Libraries," or some document—"The Handbook of the Postal Money Order System."

Legislative reference.—The legislative reference division has made a fair beginning. Its service is intended to aid members of Congress in their legislative duties. It is of interest to know that considerable work of this kind has been done in the Library of Congress, since the beginning of Dr. Putnam's administration, by the Chief Assistant Librarian and the Bibliography division.

Other special divisions.—The remaining divisions of the library are devoted to some special field of knowledge as their names indicate. They are the Music division, Map division, Manuscript division, Semitic division, and Print (Fine Art) division; these divisions require special knowledge for the proper handling of material peculiar in form as well as in content. The Smithsonian deposit which is made up very largely of scientific serials deposited by the Smithsonian Institution proves a great convenience in supplying material to the various scientific bureaus of the government. Lastly, there is the Law library, which is so much used by members of Congress that it has been found convenient to keep the greater part of the American law in the Capitol, the remainder with most of the foreign law being located in the Law division, so-called, of the Library of Congress.

Extension of influence—Catalogue cards—The Library of Congress extends its influence and service throughout the country in various ways. Through its distribution of printed catalogue cards it places at the disposal of all libraries, large or small, the best expert cataloguing, at a price much below the cost of even the crudest manuscript cataloguing, with all the advantages of legibility and permanency afforded by printers' ink. The stock of cards for sale by the Card division includes not only the books in the Library of Congress, but the books in the more important special government libraries, and during recent years manuscript cards have been accepted from the larger libraries throughout the country by the Card division and printed and placed on sale. The Card division has printed a circular of information concerning the sale of cards with the title "L. C. printed cards," which may be had on application.

Interlibrary Loans.—Through its interlibrary loan system the Library of Congress places at the disposal of scholars the riches of its vast collections, enabling them to consult at first hand publications otherwise practically inaccessible. This is not a traveling library system. It is intended to meet the need of the scholar for the rare, unusual or expensive book which the local library cannot afford to own. It is not intended to supply material for club use, for debating purposes, nor for the work of the undergraduate in schools and colleges. Librarians before attempting to use the interlibrary loan system should write to the Librarian of Congress for the little circular "Interlibrary Loans."

Publications.—A third channel through which the Library of Congress serves not only the United States but the whole world is the series of its publications covering numerous departments of knowledge, but especially important in American history, music and cartography. In American history its publications are based on its manuscript collection. Source material of the highest value is thus made available in libraries and learned institutions all over the world. The publications of the Music division, prepared under the direction of the chief of the division, Mr. O. G. T. Sonneck, who is an expert in the literature of music, are recognized as authoritative abroad in the great centers of music as well as in our own country. Worthy of special mention are the "Cataloguing of early books on music, before 1800," "Catalogue of orchestral music scores," "Catalogue of opera librettos printed before 1800," "Dramatic music, catalogue of full score" (of which a new edition is almost ready), and lastly of special interest to American libraries the "Report on the 'Star-Spangled Banner,' 'Hail, Columbia,' 'America,' 'Yankee Doodle,'" published in 1909. In 1914 a revised and enlarged edition of the chapter on the "Star-Spangled Banner" was published. This report throws much light on the origin and early history of these patriotic songs.

The publications of the Map and Chart division prepared by Mr. P. Lee Phillips, also an expert in his chosen field of cartography, are recognized everywhere as reference works of the highest value. Especially worthy of mention are the "List of geographical atlases

*From the *Wisconsin Library Bulletin.*

in the Library of Congress with biliographical notes" in 3 volumes; "List of maps of America in the Library of Congress," 1901, of which a new edition is in preparation; a pamphlet, "Notes on the cataloguing, care and classification of maps and atlases," may be had on application.

In the fields of the economic, political and social sciences the Library of Congress has published a long series of reference lists prepared in the Bibliography division. A list of these may be obtained on application.

Correspondence.—The service which perhaps reaches more citizens than any other is the response made to letters of inquiry. These letters come from all parts of the country and are on every conceivable topic. In answering such inquiries which come, of course to most of the government bureaus and libraries, a practical co-operation has developed, so that the office best fitted to answer the inquiry shall frame the reply. Inquirers will, however, save themselves much time and the government officials much trouble if they will direct their inquiries to the proper office in the first place. Questions relating to agriculture should be directed to the Department of Agriculture, on education to the Bureau of Education, on labor to the Bureau of Labor Statistics, and so on. The Library of Congress takes care of those topics not covered by special bureaus. Its replies take the form of bibliographic references to the sources of information rather than the information itself, unless the information can be comprised in a brief memorandum or the inquiry comes from some locality without library facilities. So many requests come to the library for material that it cannot be said too often that the Librarian of Congress does not conduct a traveling library system, nor does it act as a distributing center for public documents.

Serving the medical profession.—Several of the larger government libraries have attained a real distinction. This is notably true of the Library of the Surgeon-General's Office, 7th and B Streets, S. W., which is now perhaps the leading medical library of the world, containing about 525,000 volumes and pamphlets. In publishing the "Index-catalogue of the Library of the Surgeon-General's Office, U. S. Army," 1st series 1881-1895, 2nd series 1896-date, it has placed physicians all over the world under a lasting obligation, as the "Index-catalogue" is a practically complete bibliography of medical science. To Dr. John Shaw Billings, afterward director and developer of the New York Public Library system, belongs the honor of raising this library from a small bureau library to the very highest rank.

AGRICULTURE.

A little further along the Mall, at 12th and B Streets, S. W., is located the Library of the Department of Agriculture of about 150,000 volumes, a considerable number of which are distributed for convenience among the 12 or more special investigating bureaus or divisions of the department. Miss C. R. Barnett, the librarian, and her assistants in the bureau libraries, are imbued with the spirit of co-operation, every ready to place their special knowledge at the disposal of other libraries in the city.

EDUCATION.

The Library of the Bureau of Education, located in the old Post Office Department Building, 8th and F Streets, N. W., contains about 165,000 volumes and pamphlets rich in pedagogics and the educational documents of foreign governments and the States of the Union. It possesses also a valuable collection of American and foreign text-books. Here, too, the idea of co-operation has taken deep root and Dr. J. D. Wolcott never fails to respond to a call.

GEOLOGICAL.

The library of the Geological Survey, at 1330 F Street, N. W., contains about 190,000 volumes, and is one of the largest collections on geology in its broadest aspects to be found in the world. It publishes annually the Bibliography of North American geology.

A LIBRARY OF DOCUMENTS.

The Public Documents Library in the office of the Superintendent of Documents, at North Capitol and H Streets, N. W., contains about 175,000 government documents. It was begun in 1895 and has tried to secure and preserve a copy of every document published by the United States government. On its collection are based the various catalogues and check lists of public documents which have made this very difficult material now so accessible. It is not too much to say that the public documents of the United States government are the most valuable in the world for the very reason that they are so thoroughly indexed.

STATISTICAL.

The Library of the Bureau of Labor Statistics, for the present located in the Department of Commerce Building, is smaller than the libraries heretofore mentioned, having about 34,000 volumes and pamphlets, rich in everything which will throw light on the complicated question of labor. Its special collections of trade union publications and domestic and foreign labor, factory and mine inspection reports are among the most complete in existence. Its librarian, Miss M. Alice Matthews, has done much to foster the spirit of co-operation among government libraries.

RECLAMATION SERVICE.

The library of the Reclamation Service, located at 8th and E Streets, N. W., offers a fine example of the intensive use of a small, well selected library. Its catalogues and indexes are constructed with a view to bringing out everything relating to reclamation and irrigation projects, the construction of dams and reservoirs, and water conduits of every kind.

BUREAU OF STANDARDS.

The Library of the Bureau of Standards is located in one of the group of buildings constituting the plant of the bureau, on Pierce Mill Road, west of Connecticut Avenue, in the extreme northwest of the city. The library is devoted entirely to mathematics, physics and chemistry, and their technical application.

SMITHSONIAN LIBRARIES.

The libraries under the jurisdiction of the Smithsonian Institution offer an interesting group to those concerned with the natural sciences. They are located mostly on either side of "The Mall" in the vicinity of 10th Street. The largest is the library of the National Musueum, containing 45,000 volumes and about 75,000 unbound pamphlets. To meet the convenience of the curators of the various departments, which number over 30, a considerable part of the collection is distributed in the working rooms of the museum, much after the plan of university seminar collections. At the Smithsonian Institution only a small working collection is maintained on museum construction, management and development. The exchange publications received by the institution are forwarded regularly to the Library of the Bureau of American Ethnology, located in the Smithsonian Institution, B Street, opposite 10th Street, S. W., is worthy of mention on account of its valuable collection on the American Indian and Indian languages.

BUREAU OF RAILWAY ECONOMICS.

The Library of the Bureau of Railway Economics is located in the Homer Building, northwest corner of 13th and F Streets, N. W.. The bureau is not a government office, but was established by the railroads of the country to secure accurate and authentic information concerning railroads, and in order that its main function should not be impaired it is forbidden to engage in polemic or partisan discussion. The librarian, Mr. Richard H. Johnston, is a thorough believer in co-operation, and we know from experience that the valuable information and books in the Bureau of Railway Economics are at the disposal of all the other libraries in the District of Columbia. The volume published in 1911 with the title "Railway economics, a collective catalogue of books in fourteen American libraries" is practically a bibliography of the subject at the time of publication. The library, though only in existence 6 years, is already counted as one of the best railroad libraries in the country.

Cutting Efficiency and Hardness of Tool Steels

By J. O. Arnold, D.Met., F.R.S.

IN PAPERS recently read before the Iron and Steel Institute there has been a tendency to regard the Brinell and scleroscope numbers registered by hardened steels as an approximate measurement of their cutting efficiencies in the lathe. Indeed, it has been suggested that, instead of ascertaining the efficiency of high-speed steels directly in the lathe, the Brinell test might be substituted for the costly and prolonged proceeding of making systematic lathe tests. The purpose of this brief communication is to show that not only is there no relation between Brinell hardness and lathe efficiency, but also that a plain carbon turning tool with very high Brinell hardness may, on comparison with another tool of considerably lower Brinell hardness, register an efficiency of practically zero, while the tool of, say, 15 per cent lower Brinell hardness may run perfectly for, say, eighteen minutes, and during the last five minutes of the test cut cleanly at a blood-red heat before breaking down.

The Brinell hardness of a properly hardened tool is an almost negligible factor of efficiency. The efficiency depends almost entirely on the thermal stability of the simple or compound hardenites in the hardened steel. The simple hardenite of plain carbon steel has a thermal stability of which the limit is certainly less than 300 deg. Cent., while the compound hardenite of a C-W-Cr-V high-speed steel, also secured by water quenching, may be rendered stable up to a temperature of about 700 deg. Cent. The proof of the foregoing enunciation is embodied in Table 1.

If tested, *cæteris paribus*, with the steels in Table 1, a hardened best crucible-cast plain carbon steel, containing about 1.25 per cent combined carbon, would endure for perhaps two seconds. Therefore its endurance would be roughly 0.3 per cent that of the W-Cr steels and about 0.2 per cent that of the W-Cr-V steels. Nevertheless, its Brinell hardness would be about 700 as against the 600 numeral registered by the high-speed steels. Again, according to the mean Brinell test (602) the W-Cr steels should average an efficiency of 0.3 per cent greater than the constant numeral (600) of the W-Cr-V steels, yet the actual efficiency of the latter is 63 per cent greater than that of the former. In a word, the Brinell and scleroscope tests, while valuable means of rapidly approximately determining the elasticity of structural steels, are valueless, or indeed worse than valueless, for estimating the varying thermal stabilities of the hardenites which mainly determine lathe efficiency.

The author and Prof. A. A. Read, D.Met., have shown (*Proc. Inst. Mech. Eng.*, November, 1915, p. 645) that there are four single hardenites; i. e., solid saturated solutions of carbides, namely, iron hardenite ($Fe_{21}Fe_3C$), vanadium hardenite ($Fe_{74}V_2C_3$), tungsten hardenite ($Fe_{28}WC$), and ferro-molybdenum hardenite ($Fe_{21}Fe_3Mo_3C$), (this substance might be accurately classed as a sort of double hardenite). The double, triple, and possibly quadruple hardenites of high-speed steels yet remain to be discovered, but owing to a grant-in-aid of £200 from Sir Robert Hadfield, the author, and Prof. A. A. Read, D.Met., of the University of Wales, are now proceeding with this complex research.—A paper read before the Iron and Steel Institute May 5, 1916.

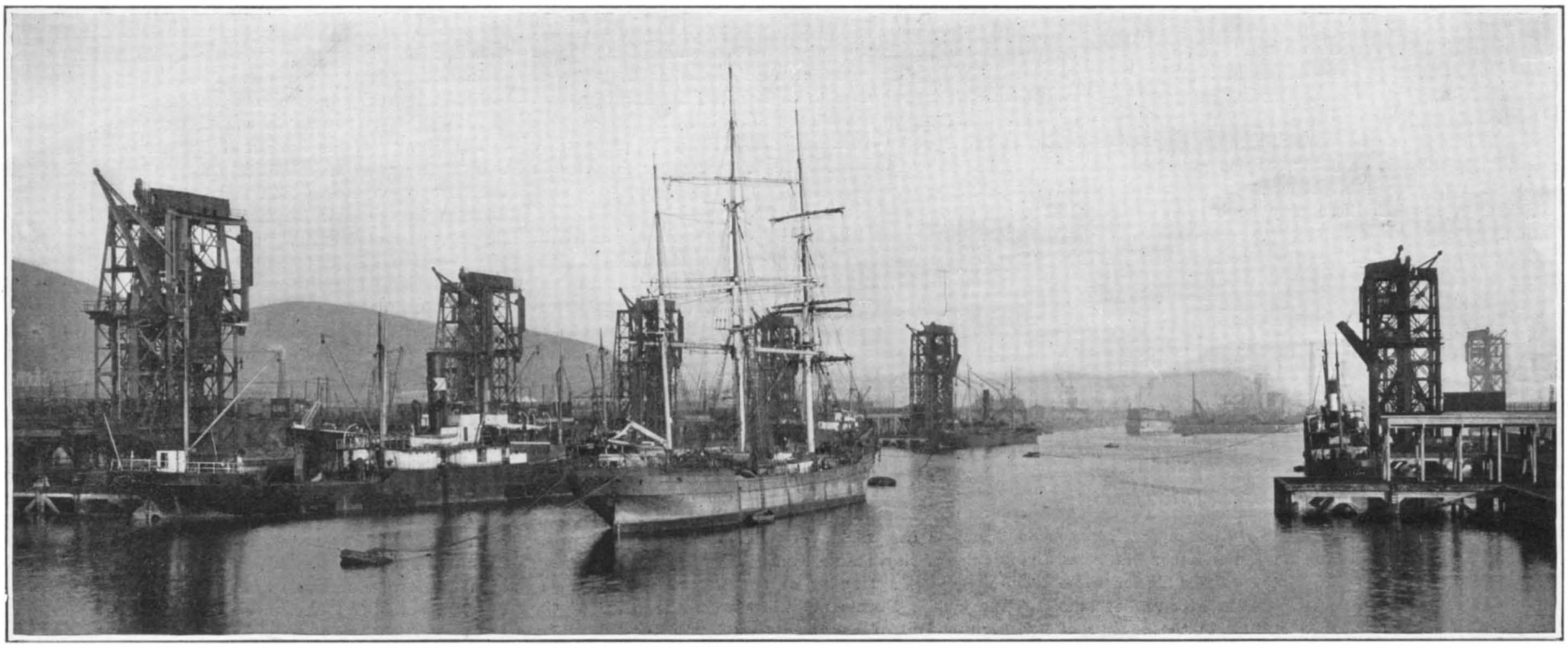
TABLE I.

University Steel No.	Type of Steel. Compositions Nearly Identical for Each Type.	Duration of Tests in Minutes and Seconds Before Breaking Down. 1st Grinding.		2nd Grinding.		3rd Grinding.		Mean.		Efficiency. Cubic Inches of Standard Hard Steel Shaft Removed. 1st Grinding.	2nd Grinding.	3rd Grinding.	Mean.	Brinell Hardness No. Pressure, 3,000 Kilos.; ball, 10 mm. diameter.	Scleroscope Hardness No. Average of Four Tests.
		M.	S.	M.	S.	M.	S.	M.	S.		(a)				
1523	Tungsten-chromium....	10	7	11	45	9	26	10	26	47.4	56.3	43.3	49.0	600	82.8
1527	Tungsten-chromium....	11	25	12	35	10	32	11	32	54.7	61.4	49.4	55.2	629 (b)	80.5
1523	Tungsten-chromium....	10	26	11	50	11	31	11	18	48.9	56.7	55.0	53.5	578	80.3
1522	Tungsten-chromium vanadium...........	14	17	17	59	13	40	15	19 (c)	72.3	96.2	68.0	78.9	600	80.3
1524	Tungsten-chromium vanadium...........	17	2	17	49	16	57	17	24 (c)	91.0	95.2	89.1	91.8	600	75.5
1528	Tungsten-chromium vanadium...........	16	2	17	52	16	57	17	24 (c)	84.1	95.7	89.1	89.6	600	76.3
1534	Tungsten-chromium.... vanadium...........	15	21	17	10	15	45	16	27 (c)	79.0	91.6	81.1	83.9	600	81.0

NOTE.—The Brinell and scleroscope hardnesses were taken as near as possible to the hardened cutting edges of the various tools.
(*a*) It will be seen that with both types of steel the maximum efficiency is obtained on the second grindings of all seven tools.
(*b*) Duplicate test 629.
(*c*) Throughout these tests the cutting edge of the tool was red-hot at the breakdown points, and, indeed, for about five minutes previous to breaking down.

Producing High Vacua

WHEN a very high vacuum is desired finely divided copper, such as is obtained by reducing a solution of a copper salt, and commercially known as "precipitated copper," may be used with advantage to absorb the last traces of gases, which it takes up rapidly. When used for this purpose a few grammes of the copper are placed in a bulb which is sealed to the vessel to be exhausted, and while the copper is heated to about 250 degrees, to free it of any gases it may be holding, an air pump is operated to effect a partial vacuum. The pump is then disconnected, and as the copper cools it rapidly absorbs the remaining gases. This absorption is not a chemical action, as the gases are again liberated when the copper is heated.



King's Dock at Swansea, Wales, showing extensive coal-handling equipment

British Methods of Handling Coal

Great Machines Employed for Loading Vessels at the Docks

By James Steelman

In normal times Great Britain and Germany together produce in a year something in excess of the coal mined in the United States—Great Britain being in advance of Germany. An enormous output of the English and Welsh mines has been going on for many years, so that their methods of handling coal at tidewater have become well developed. In order that Americans may gain a right conception of these it is very necessary to know some of the fundamental conditions.

British coal cars are, when compared with those used in the United States and Canada, diminutive affairs. A full sized American car carries about 45 or 50 tons. The recently introduced monster cars of the Norfolk & Western Railway have a capacity of 90 tons. American coal cars are carried on two trucks which must have at least four wheels apiece. In the case of the Norfolk & Western cars there are six wheels to the truck. In Great Britain it is a big coal car that carries 20 tons. I do not know that any of them have trucks. Instead of steel, wood is used for the body. However, bigger cars are coming into use. For example, one colliery on the North Blyth mineral line of the North-Eastern Railway put 40-ton cars into use half a dozen or more years ago.

Nevertheless, there is a good deal of handling the same in the two countries. This remark applies very well to the transfer of coal from rail to ship. The chief districts where such operations are to be seen are the coast regions of South Wales and Northeast England. Here are such shipping points as Swansea, Barry and Cardiff in Wales and Newcastle and Hull in England.

Both in Great Britain and in America the car tip is largely in evidence. But the British tip their cars endwise; the Americans, sidewise. Further, end tipping seems to require some method of opening one end of the car. American side tipping imposes no special features of car construction.

The handling device shown on the front cover is a crane located on a dock at Liverpool. The pedestal, carrying the whole apparatus, may be shifted along the wide-gage track and thus suit its position to that of the moored vessel. This machine is capable of handling loads of 25 tons. The crane may be rotated, so that the loaded car may be lifted from a position at one side of the pedestal and then swung outboard over the hatchway of the vessel. A vertical lift of 50 feet is possible, though of course not always necessary. Close attention to the view will show that the car is lifted by means of and along with a short length of track. This is termed a "cradle."

A typical cradle is provided with stops which engage the front axle of the car to be tipped. At the other end the car is held by securing the draw chain to a fixed piece called the anchor hook. The cradle with the loaded car is then lifted and swung to approximate position. The end door must, of course, be directly over the hatchway. A workman operates a line which swings the cradle. This movement of the cradle is made possible by a swivel arranged on the hoisting gear. After the load has been discharged, the crane is swung back and the hoisting chain paid out. There are guides which cause the cradle to settle into correct alignment with the track. The front end of the cradle comes first into contact with the rails, this result being secured by the proper adjustment of the length of the chains. The car starts back, the stops are lowered so as not to interfere with the axles, a lever located at one side of the cradle providing a means for this, and the next loaded car is drawn onto the cradle, forcing the "empty" off. The release of the lever permits the stops to be returned to normal position by the action of suitable springs. An alternative method, which may be used where it seems desirable to introduce the loaded car at the front end of the cradle, provides by the shape of the stops for automatic depression when the oncoming axles strike them. As soon as the new car is fairly on the cradle, springs come into action and erect the stops. Whenever the whole towerlike structure has to be shifted along the dock, the guides and cradle may be coupled together by links provided for this purpose and the whole transported by the crane.

An advantage of this type of coal handling device is that it may readily be employed in other dock service. It is only necessary to detach the cradle from the beam from which it is suspended and make use of a large shackle at the end of the swivel. The machine may then be employed in transferring to or from the dock heavy articles such as boilers and the like. There seems to be no substantial reason why this crane could not be used for lowering bottom-dump cars down into the hold and there discharging them with a small relative amount of breakage. There would, perhaps, need to be some more effective method of controlling the orientation of the car during the period of entering and leaving the hatchway.

At Sunderland, on the northeast coast of England, in the Northumberland-Durham coal section, it was felt to be highly desirable to make an especial point of avoiding breakage of the coal. Furthermore, the vessels engaged in the trade are chiefly rather small, low-lying affairs. Here, in consequence of the conditions, we have one of the most novel coal-handling devices to be found anywhere in the world. The loaded car is taken from an elevated position at the water's edge and brought down into a low position—into the very hold, if desired—and there discharged through the bottom of the car. The empty car is then returned to the elevated track and allowed to run off to a suitable place. The car is not tilted or overturned—it is always right side up. A rather surprising feature of the operation consists in the fact that normally neither in the lowering of the loaded car nor in the return of the "empty" is power employed. Gravitation performs both operations. The only times that power is needed are when it becomes necessary to return the car with all or part of its load. Such an occasion might arise if a frozen load refused to move, or if the whole of the load were not needed to finish trimming the vessel.

Essentially, the device consists of a pair of duplicate two-armed levers fulcrumed on a horizontal axis between the two ends. When not in operation, both levers stand obliquely in vertical planes perpendicular to the water front, the upper ends leaning toward the water. A bar connects these upper ends. On it is swung a platform on which has been laid a short section of railway track. Here the car stands during the lowering and returning operations. It will be understood that at the beginning of a cycle of movements the short track on the platform will be a continuation of the elevated track by which loaded cars come to the water front in a direction perpendicular to that front.

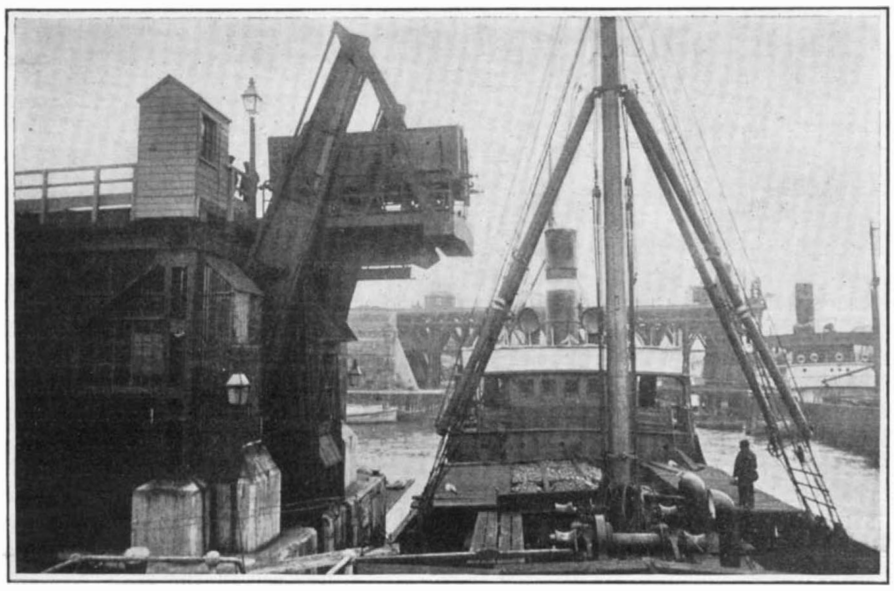
The upper arms of the levers are longer than the lower arms. The latter are counterweighted to such an amount that when the platform with the loaded car upon it is released, platform and car will move forward and downward at a good but not too rapid speed, and that when the load has been discharged platform and car will return promptly, but not violently fast. Whenever power becomes necessary in order to secure the return, a pinion-and-rack device, the rack being an arc of a circle, is brought into requisition. This is arranged at the bottom end of the lever contrivance. The control of the apparatus when lowering loaded cars by gravity is secured by braking arrangements.

At Middlesbrough, also on the northeast coast, is located a handling device which depends for the accomplishment of its purpose upon two conveyors, one of which delivers to the other by means of suitable chutes. The loaded cars come to the immediate vicinity of the water front upon a track paralleling the dock front. The level of the track is but a very few feet above that of high water of ordinary spring tides. A ship's hatches may at times be above the track. Accordingly, the coal from the cars must be elevated as well as transported from track to ship.

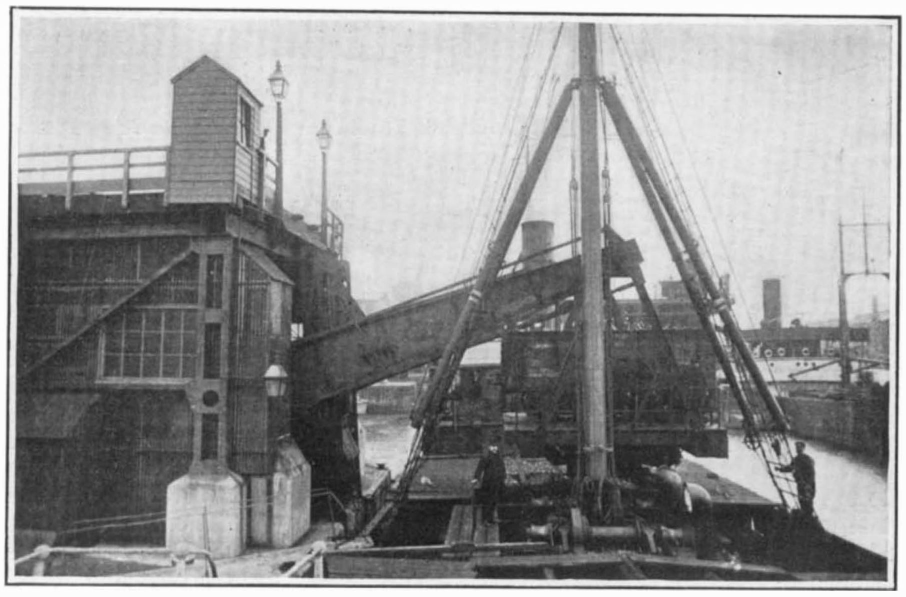
A tower stands a few feet back from the edge of the dock. The coal is carried by one conveyor to a point in this tower at an elevation of, perhaps, 35 or 40 feet above its base. On the water side of the tower a long boom is hinged or pivoted. This boom carries the second conveyor by means of which the coal is delivered into the hold of the vessel. The boom may have its outer end depressed below or elevated above the fixed level without interference with the operation of the conveyor which it carries. The outer end may, in fact, be elevated to a much higher level, but this is not a working but a housed position.

The coal is taken from beneath a hopper constructed underneath the railway track at a point opposite the tower. The shape and arrangements of the hopper are such that coal is delivered to the belt with only a moderate shock. The coal is delivered to the hopper, which has a capacity of some 30 tons, from the overhead railway cars.

The conveyor which connects hopper and tower is a composite band 42 inches wide, which band is driven



Twenty-ton coal-loading apparatus at Sunderland Docks. Loaded wagon about to be lowered.



Loaded car lowered by swinging arms to the hold of the ship.

as an endless loop, the working half of which is carried by idle rollers arranged in transverse groups at intervals along the incline leading to the tower. A normal group of rollers will be so arranged as to permit the band to form a shallow trough. The incline makes with the horizontal an angle of about 20 degrees, which is less than the maximum angle of repose for coal. The belt is driven from the tower end, where it is carried around arcs of two wheels so that a rather firm grip upon the loop as a whole is obtained. The tendency to sag due to lengthening of the belt from continuous use is corrected by means of a tension gear. The belt is supported on its return by idle rollers.

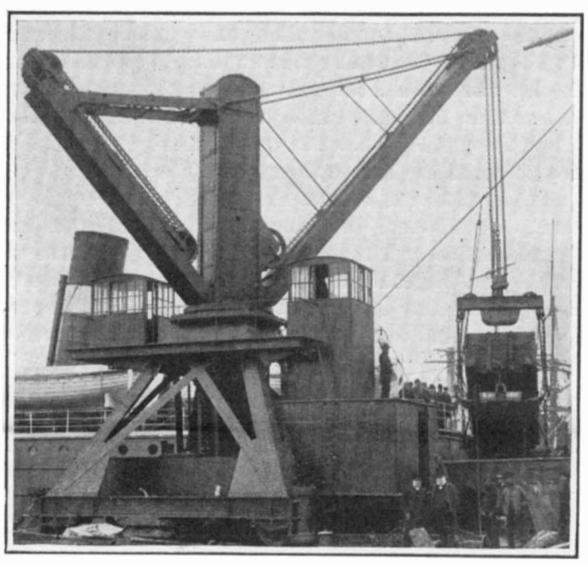
The conveyor carried by the boom is made up of steel trays which are connected to form an endless chain. The limitation of the working position of the boom to 18 degrees above the horizontal is doubtless due to a tendency of the coal to slide back on the conveyor plates when the elevation is higher. The boom may be so much depressed at times, the amount of depression depending upon conditions at the moment, that the conveyor need not be driven, but simply used as a chute. The boom weighs some 1,900 pounds. It is elevated and depressed by means of a hoisting rope secured at a point about 13 or 14 feet from the outer end by means of a suitable bridle carrying a sheave.

This handling apparatus is quite flexible with respect to the point of delivery, as indeed is necessary because of the variations due to heights of hatchway above water line, depths of settlement of boats into the water, changes of tide, etc.

Hull, near the northeast coast of England on the River Humber, is said to be the third greatest coal shipping point in the United Kingdom. The yearly tonnage totals about 7,000,000 or perhaps 8,000,000. This shipping point can be reached by 400 collieries by railroad. There are forty or more coaling berths from which it is possible to take on about 15,000 tons per hour. Apparently, the ratio of actual use to capacity of the coal facilities at Hull is far below that for any one of our principal Atlantic coal harbors—New York, Philadelphia, Baltimore and Hampton Roads. The American harbors utilize their facilities to the extent of from 30 to 50 per cent of their capacities, while at Hull the percentage appears to be less than 20. At 15,000 tons per hour, even an 8-hour working day will correspond to 120,000 tons. So that for 8⅓ working days, the capacity would be 1,000,000. The total annual shipment could accordingly be handled in 58 working days—that is, in about one sixth the working time of a year.

Just before the beginning of the war additions were being made to the coal handling facilities. These were being installed upon Hull Joint Dock, a new dock and the largest on the northeast coast. The coal handling additions were to have a combined capacity of 5,000 tons per hour, and consisted of five electrically operated belt conveyors and a fixed and a movable hoist. The water area of the dock amounts to 53 acres, and provision has been made for ultimate extension to 85 acres. A large part of the wharf frontage of 1½ miles is given over to coaling berths, six in number. These berths are arranged *en echelon*, permitting six vessels of the largest size to be loading at the same time. This arrangement provides for the independent arrival and departure of each of the six vessels. In 1914 two of the five conveyors were being installed. Both these and the hoists have presumably been completed long ago and put into commission. As both high and low level sidings are included in the arrangements, the provisions are to be understood as covering both power and gravity operation of loading appliances.

Some few years ago, on the same River Humber, but on the opposite shore, and nine miles farther inland from Hull, the Immingham Dock was opened. This dock is reached from the Humber by an entrance lock. The dock itself is a rectangular body of water into which from the northwest side a long pier projects. The coaling facilities are ranged all along the southwest side of the dock, a frontage of something less than half a mile. Here



Movable end tipping crane.

seven coal hoists have been installed, six fixed and one movable. The movable tip is capable of handling cars having capacities up to 20 and 30 tons. The cars are tipped endwise at any level between 18 and 60 feet above the wharf. The tip may be shifted to any point of a 300-foot frontage. The six fixed hoists have capacities of 30 tons. Five of them lift to the 71-foot level, and one

Fixed hydraulic tip.

to the 56-foot, the loaded cars entering the hoists at wharf level. The "empties" are run off on viaducts elevated, perhaps, 20 or 25 feet above the wharf. This feature of dispatching the "empties" at an elevation seems to be unused here in the United States. In accordance with American practice, the car dumpers are located with their bases at an elevation. This bottom level of the cradle requires that the loaded cars be gotten up an inclined approach by some power system—ordinarily a small cable car operating on a track intermediate between the rails of the full gage approach track. At first sight, it might seem advantageous to eliminate the auxiliary arrangements used to get the loaded car up to the elevated position of the cradle and perform the hoisting operation as a single movement from the general track level to the dumping point. The American method of dividing the lift is considered advantageous because it permits *both* lifting operations to be carried on simultaneously and so makes possible the rapid handling of cars.

At Immingham, before the main dock was finished, coaling facilities were provided on the water front of the river itself. An entrance jetty after reaching out into the river for some 650 feet turns a right angle and parallels the shore. Upon this arm of the jetty a coal hoist was set up. The one eighth of a mile of water intervening between jetty arm and shore was bridged by two steel structures carried on cast iron cylinders. Each of these bridges carried an upper and lower track laid on separate floors. The tracks were so arranged that the lower ones provided a downgrade of 1 in 90 to the hoist and the upper ones a down grade of 1 in 75 away from it and toward the shore. In this way provision was made to handle the loaded and empty cars in going to and away from the hoist without the use of power. This hoist deals with cars ranging from 10 to 20 tons capacity, and secures the proper discharge of the loads whether the cars happen to be constructed for end dump or bottom dump. The cradle on which the cars stand when going up and coming down is so managed that when ascending it is inclined somewhat toward the delivery side of the tower and when descending and approaching the upper level of a bridge it is tipped toward the run-off track.

Contagion From Clothing

In a paper read at Paris before the Academié de Medecine, Prof. Trillat treats of the conditions in which clothing and other objects enter as elements to transport disease germs. Clothing as a culture-medium is a point which he studies specially, and observes that noxious microbes abound in clothes on account of moisture and gaseous emanations coming from the sudorific glands and the lungs. He brings out an interesting fact that various fabrics show differences in being more or less favorable media for the cultivation of microbes. Silk and cotton appear to be less dangerous than woolen garments. Again, as to the best means of overcoming the difficulties, he considers that it is very effective to expose garments to the rays of the sun, for this has a remarkable action in destroying the disease germs.

A Generating Station Danger

Attention is being directed to the danger resulting from the presence of the oil switches used in all electric generation stations. An ordinary set of these instruments contains many hundred gallons of oil, and, as they are necessarily located in close proximity to the switchboard, a fire in one of these switches would result in extensive damage. Such a fire is always possible, and the large volume of quickly spreading inflammable material would, in all probability, spread a fire so completely among the network of wires as to result in a lengthy suspension of operations in the station. A safer device is wanted, and quickly too; the only wonder being that the dangerous oil switch has been tolerated so long, difficult as it is to supplant it.

Modern Views of the Sun—II*

An Important Star Whose Real Nature Is Only Beginning to Be Understood

By J. S. Plaskett

Concluded from Scientific American Supplement No. 2116, Page 51, July 22, 1916

From the researches I have been discussing, it is evident that we have a clear conception, probably not far from the truth, of conditions in the sun's atmosphere or chromosphere, of the distribution in height of the various elements, of their circulation in prominences, and especially in sun-spots, and we find that, perhaps except over sun-spots, they appear to be entirely gaseous and are in general at a high temperature, though, of course (and this is evident from the dark line spectrum produced), in the outer layers considerably lower than the photosphere.

But hitherto, except for ascertaining that the temperature of the photosphere is not less than 6,200 deg. C. and possibly near 7,000 deg. C., 12,000 deg. F., we have not hazarded any hypothesis as to its constitution and physical condition, still less, as to the conditions below the photosphere in the interior of the sun which appear to be hopelessly beyond direct investigation. The comparatively low density of the sun, 1.4 times water, taken in conjunction with its enormous gravitational force, seems to point to a gaseous constitution of the interior. This view is strengthened by the enormous temperatures that must prevail in the inside of a globe whose outer visible surface is at a temperature of nearly 12,,000 deg. F., which must increase with the depth. Any of these temperatures are probably above the critical temperature at which liquefaction can take place; and though it is possible that the enormous pressures and temperatures in the interior of the sun may in some way modify the ordinary gaseous properties, it seems very unlikely that it can be either solid or liquid.

If the sun is wholly gaseous we have to answer the question: What causes the bright photosphere and what produces the apparently sharply-defined boundary between it and the upper atmosphere or chromosphere? The view probably held, until very recently at any rate, by most astronomers was, perhaps, most clearly expressed by Young, in his book on "The Sun," who says: "It seems almost impossible to doubt that the photosphere is in a shell of clouds. As to the precise constitution of this shell, however, the form and magnitude of the component cloudlets, the chemical elements involved, and the temperature and pressure, there is room for a great deal of uncertainty and difference of opinion. The more common view apparently . . . is that the clouds are formed mainly by the condensation of the substances which are more conspicuous in the solar spectrum, such as iron and the other metals. As to the form of the clouds also, it has usually been assumed that, as a consequence of the ascending currents by which they are formed, they are columnar, their heights being much greater than their other dimensions." It is evident that the rice grain structure is readily explainable by this hypothesis, and the spots, faculæ, prominences and chromosphere do not offer any graver difficulties than would be met with in other hypotheses.

The question of temperature, however, is a serious objection, as it is now practically certain that the radiating surface, the photosphere, the "shell of clouds," according to Young, is at a greater temperature than 6,000 deg. C. Moissan placed the temperature of his electric furnace at 3,500 deg. C., and stated that all known elements were vaporized at that temperature. Under these conditions it does not seem possible to have a photosphere of condensed droplets of metals, and other explanations of its nature have been advanced.

The theory of Schmidt explains the sharp boundary of the photosphere by assuming that it is wholly gaseous. Owing to the curvature of the rays of light by refraction through the solar atmosphere, whose density must rapidly increase with the depth, the refraction would become so great at a certain diameter of the sun that the line of sight from the earth would be curved sufficiently to pass around and around the sun. At a greater diameter the line of sight would pass through the outer layers of gas and emerge on the other side. The sharply-defined limb would evidently be the limiting diameter where the refraction would be such as to cause the line of sight to follow around the circumference. Although this optical hypothesis gives a reasonable explanation of the photosphere, matters are considerably complicated when we attempt to explain sun-spots, and it has not received much acceptance from observers of solar phenomena.

Julius has also advanced an interesting theory which explains solar phenomena by the effects of anomalous dispersion, and though astronomers are willing to admit that anomalous dispersion may have some place in modifying the observed effects, Julius's views have received even less acceptance than Schmidt's.

Abbot in his recent book, 1911, on "The Sun," has elaborated a theory, first generally stated by Secchi and contributed to by Schuster and Schwarzschild, which seems to explain in a satisfactory manner most solar phenomena. In this theory it is assumed that the sun, except perhaps in sun-spots, is wholly gaseous and vaporous, the photosphere being too hot to contain solids or liquids. Further, the density of the gases rapidly diminishes and their temperature rapidly falls from within outward across the apparent boundary of the sun. Abbot explains the sharp boundary of the photosphere by the molecular scattering of the light in passing through the layers of gases and vapors surrounding the sun, and computes, based on the work of Rayleigh and Schuter, that this gaseous scattering would prevent us seeing farther than 5,000 miles into the interior when lookng at the center of the sun, and to less than 500 miles when looking at the limb. This latter amount is sufficiently small, about one second of arc, to make the limb appear sharply defined.

He answers the objections of the advocates of a cloudy photosphere that the enormous radiation into space must so cool the outer layers as to condense vapors, by stating that the visible photosphere, the "cloudy" layer, is certainly above 6,000 deg. C., at which temperature no vapors can condense, and that the conveyance of heat from the interior is so rapid as to maintain the temperature at this high level.

Another argument against the cloud theory that has occurred to me may be interpolated here. If the temperature of the cloudy layer is low enough to condense some of the vapors, why are not these same vapors in the reversing layer, which produce the dark lines in the solar spectrum and are admittedly at a lower temperature and higher level, also condensed? Furthermore, the lighter non-condensible elements, such as hydrogen and helium, which are admittedly incandescent to the height of about 10,000 miles, may serve as a sort of intermediary between the high temperature of the photosphere and the low temperature of space, and maintain the temperatures of the lower level metallic vapors above the condensing point.

The rice grain structure of the photosphere is easily explained on this hypothesis by differences of temperature caused by irregularities of convection and radiation, while the fundamentally continuous character of the spectrum of the photosphere can be produced by gases in thick layers under high pressures. The darkening toward the limb follows naturally as we see farther into the interior at the center of the sun and hence to layers of higher temperature, and brighter, than at the limb.

The phenomena of the absorption lines in the solar spectrum, of the reversing layer, upper chromosphere and prominences, as well as of the corona, of which time permits only the mention, are at least as readily explainable on this hypothesis as any other, and the same is true of sun-spots, of which a working hypothesis was given above.

What we have hitherto said gives us a clear idea of the mechanism of the sun's outer atmosphere, of its distribution, currents and motions, but tells us nothing as to the fundamental cause of the eruptions which produce spots and prominences, nor as to the reason for the cyclical changes which they go through. Further, the change in the speed of rotation for different latitudes, and, still more remarkable, the variation of this speed, which now seems to be well established, remains a mystery. Various theories by Secchi, Faye, Oppolzer, Halm, Emden and others have been advanced to account for these phenomena, but in view of our absolute lack of direct knowledge of what goes on below the photosphere, it is evident that, even if time permitted, little of definite value could be said of the nature and cause of these deep-seated phenomena.

We have hitherto spoken only incidentally of what is to us certainly the most important function of the sun, its radiating power, by which all life on our globe is sustained. The determination of the quantity of heat reaching the earth from the sun has long interested physicists and astronomers, but it is only within comparatively recent years that accurate measurements of this quantity have been made. It is chiefly to the labors of Langley and his successor in this work Abbot, that we now know that the average radiation reaching the earth's atmosphere is nearly two calories per square centimeter per minute. Somewhat more than one third of this quantity is absorbed by the earth's atmosphere and the other two-thirds reaches the surface. More recently Abbot has shown, by the most careful and accurate work, that the mean yearly values of this radiation vary over a range of perhaps five per cent, being greater at sun-spot maximum than at minimum. In addition to this long-period range, there seem to be short-period oscillations, more or less irregular, of a somewhat greater magnitude, varying altogether between 1.8 and 2.0 calories, but over any single short period the range not exceeding five per cent. It is easy to correlate the long period changes with the variation of the solar activity, but as to their actual fundamental cause, we are as much at sea as in the case of other solar phenomena. It will be interesting to see whether these changes in radiation, especially the short-period ones, can be connected with meteorological changes and whether, therefore, they can be used in weather prediction.

If the sun is emitting energy at the rate of two calories per square centimeter per minute at the distance of the earth, it is evident that its total emission will be twice the area in square centimeters of the surface of a sphere 186,000,000 miles in diameter or that the sun radiates 525 followed by 25 ciphers calories per minute.

If the sun were a body cooling without any means of replenishing its stores of heat, this radiation would cause it to fall in temperature about 1.4 deg. C. per year, which would be about 3,000 deg. C. within historic times. As the radiation varies with the fourth power of the temperature, the earth two thousand years ago would have been receiving five times as much heat as at present, which is manifestly not the case.

What then maintains the energy of the sun at a constant or nearly constant rate of emission? Some idea of the enormous quantity of heat given out will be evident when it is stated that it would require the burning over the whole solar surface of a layer of anthracite coal twenty-three feet thick every hour. At this rate, if the sun were made entirely of carbon, it would not have lasted five thousand years.

A theory brought forward by Mayer, about the middle of the last century, assumed that the solar energy was maintained by the falling of meteorites into the sun. Such bodies would reach the sun with a velocity of about 400 miles per second and would generate on impact more than 6,000 times the heat of an equal weight of coal. To maintain the sun's heat there should fall on every square yard of the sun's surface about two pounds per hour. This would increase the solar diameter about one second of arc in 5,000 years, a quantity impossible to detect probably in less than 2,000 or 3,000 years. But the increase in mass of the sun would affect the length of the year, shortening it by about one eighth of its value in 2,000 years. Furthermore, sufficient meteoric matter in the solar system to maintain the sun's heat would cause the earth to receive ten million times as much as at present and either one of these deductions is sufficient to cause the rejection of the theory.

The theory now generally accepted as being the principal cause in the maintenance of the sun's heat—its shrinkage under its own gravitational force and the transformation of the work done by this shrinkage into heat—was first proposed by Helmholtz about 1853. It has been computed by various writers that a shrinkage of about 250 feet per year in the diameter is now sufficient to make up for the loss by radiation. Newcomb calculated that it will require to shrink to about one half its present size to maintain the present rate of radiation for 7,000,000 years. Further, if the original nebula, which, on condensing, formed the sun originally filled a sphere whose diameter was that of Neptune's orbit, it would have furnished about 25,000,000 times as much energy as the sun now loses in a year.

If the rate of giving out energy had been constant this would make a period of 25,000,000 years during which the earth had been receiving heat as at present.

*Address of the retiring president of the Royal Astronomical Society of Canada at its annual meeting, 1916. Republished from the *Journal* of the Society.

In various ways geologists have estimated the age of the earth as somewhere between 50,000,000 and more than 100,000,000 years, with most of them inclining to the longer period, and the difficulty arises of explaining the discrepancy between the 25,000,000 years and the much longer time required for geological processes on the earth.

It was thought when radio-activity was discovered that this hitherto unknown source of energy might serve to bridge over the gap between the astronomical and geological epoch. But it seems doubtful at present, and is not yet definitely settled whether radio-active processes are or have been considerable sources of solar energy.

It seems to me quite probable that in the earlier stages of the sun's and earth's history the greater internal heat of the latter, and possibly different atmospheric conditions, may have markedly accelerated the geological processes, while at the same time the sun may not have been radiating at so rapid a rate. Its greater diameter in early ages would also, probably, affect matters favorably so far as reconciling the two views are concerned. It is possible that by such means the life of the sun could perhaps be extended to fit the geological estimates or the latter may by later researches be diminished. However this may be, the contraction theory seems the only one in sight for accounting for the maintenance of the solar radiation.

I have by no means been able, in this paper, to cover even a small fraction of the ground required to adequately treat this subject, but I hope sufficient has been said to give you some idea of the most recent views on the constitution of our luminary and to show you that we are, probably, only on the threshold of what we may hope to learn by improved methods about this, to us, most important star of the universe.

The Process of Case Hardening*

A Method of Heat Treatment, of Great Importance in the Mechanical Art

By R. A. Millholland

There is an axiom that always comes into my mind whenever the subject of case hardening is mentioned, and it is this: The depth of carbon penetration in case hardening depends on the time of heating and the temperature at which the work is heated. This is not a new theory in case-hardening practice by any means, for it has been known for a considerable number of years by a very few clever men who did not see fit to talk much about the matter, preferring to keep it as a trade secret. Another good axiom to heed is, high temperatures produce poor results. By high temperatures I mean temperatures above 1700 deg. Fahr. The proper case-hardening range lies between 1600 and 1700 degrees.

There are an infinite number of reasons why the higher temperatures should be avoided in case hardening. The greatest reasons are: First, the use of temperatures above 1700 deg. Fahr. for case hardening will cause too much carbon to be absorbed in the carbonized area and a supersaturated case is the result; second, the high temperatures will cause excessive crystallization of the steel that is being carbonized and serious difficulty will be experienced in refining both the case and the core. Between 1600 and 1700 deg. Fahr. the core structure is not very materially changed by the ordinary heating time, which on a rough average is about 4 hours. Crystallization does take place to a certain extent, but the refined structure is quickly restored by careful treatment. The lower carbonizing temperatures minimize the possibility of the pieces warping during carbonizing. Temperatures below 1600 deg. Fahr. are, as a general rule, impractical from the economical standpoint, if for no other reason. The speed of penetration is so much greater at 1600 to 1700 deg. Fahr. that it is impractical to use the lower temperatures where cost is an item to be considered. The depth of penetration varies in a direct ratio with the temperature; that is to say, at 1700 degrees more carbon penetration will be secured in a given time than will be secured at 1600 deg. Fahr. in the same length of time.

The time and temperature factors are very important in case hardening, and to strike a happy medium of temperature and time, is at once both highly desirable and very difficult. A disregard of either factor will result in disaster. On several occasions I have been asked why certain steels seemed to burn out when they had been subjected to long carbonizing heats. Never in all my experience did I find the steel to be the real cause, in almost every case it was due to the use of temperatures above 1700 deg. Fahr. Generally coupled with the overheating, the practice of dumping the parts directly from the pots was employed. Both are very poor practice, but the combination of the two is bound to give some mighty poor results. A certain manufacturer was trying to defend the practice of dumping directly from the pots, but he admitted that his product gave 100 per cent more service when reheated to refine the core, and he showed me several test records to that effect.

SHORT CUTS TO BE AVOIDED.

The writer could cite innumerable incidents to prove the superiority of complete heat treatment over the short cuts that are so often used to economize on case-hardening expense. "Safety First" signs are conspicuously displayed in almost every shop in the country and yet the manufacturer, in some cases, still clings to the before-Noah-and-the-Ark practice of quenching the carbonized pieces directly from the pot, and calling the case-hardening operation complete. It is always best, when at all possible, to allow the parts to cool in the pots before they are removed from the carbonizing compound. There is a dual reason for doing this. The first is that the carbonizer is saved from oxidation by the air which would render it almost useless for further service, and the second reason is that on heats longer than 4 hours the crystalline structure of the core is so coarsened that the hardened part will not have the strength consistent with the factor of safety, upon which principle all conscientious manufacturers build their products. However, on heats of less than 4 hours, it is generally the case that the parts can be quenched from the pot and then treated to refine the case, which will give a result that will fill all but the most exacting requirements. The one objection to this practice as applied to this particular method is that the carbonizer can only be used once before it loses much strength. The reason is that the air, containing as it does a large per cent of oxygen, oxidizes the carbon in the carbonizer and makes the carbonizer useless for further work. If, however, a cheap carbonizer is used, similar to one of those I have already mentioned, a material saving in actual carbonizing cost can be effected.

On work of a larger nature which requires a longer heating time than 4 hours, it is essential to treat both the core and the case. Especially is this true of parts that are subjected to shock and vibration. To the uninitiated it is astounding to see what the actual difference is betwen a properly and an improperly treated case-hardened part. It is safe to put the difference in strength at a minimum of 50 per cent for both the tensile strength and the resistance to shock.

METHOD OF TREATING CASE AND CORE.

Now let us consider the most practical method for treating both the case and the core to secure the best results. After the piece has been carbonized the first object is to refine the core. The practice in all cases is the same, whether carbon or alloy steels are being treated. The only variation to be considered is the critical temperature of the original steel as received from the mill prior to the carbonizing operation. In the standard mill specification open-hearth, case-hardening stock the critical temperature is very close to 1650 deg. Fahr., and is the one at which the core of the case-hardened part should be treated.

There are many different methods for doing this, and I shall only touch briefly on the two most important ones. For rough work that is to be ground all over after hardening, or for work that will allow a slight amount of distortion and scale, I believe heating in the open furnace to be the most economical method that can be employed. A large amount of work can be handled rapidly, materially reducing the amount of labor per piece. The ordinary commercial heat-treating furnace can be used to the best advantage. By a pyrometer or some other device the temperature of the furnace should be regulated to 1650 deg. Fahr. and the furnace charged with the parts to be treated. It is essential that the temperatures of the furnace be regulated as nearly correctly as possible in order that the steel is not over heated. When the parts are thoroughly saturated with heat and the pyrometer indicates that the heat is what it should be, the work should be quenched in a heavy oil. From careful experience and experimenting I find for quenching from the higher heats employed in heat treatment that an oil having a specific gravity of 22 Baumé, a flash point of 420 deg. Fahr. and an ignition temperature of 480 deg. Fahr. is suitable. These specifications conform to practically all fire insurance regulations, and at the same time the oil can be obtained at considerably less than the many special oils sell for.

The other method for treating the core is used chiefly on transmission gears and ordnance equipment and anywhere the distortion and scaling must be held to a minimum. The lead bath is used in this method to heat parts. The lead is heated in crucible furnaces designed for that purpose and the parts are immersed in the molten lead and held there until they are thoroughly heated and then quenched in practically the same manner that the furnace treated pieces are. The advantage of this method is that the pieces are uniformly heated in a bath that excludes all air and prevents oxidation. The result is that the parts come from the oil free from scale and distortion is reduced to a minimum. In both methods the work should be transferred from the furnace to the oil quenching tank as quickly as possible to secure the greatest strength in the core.

Following the treatment of the core the case should receive even more careful attention than the core. A hard surface is the primary object of case hardening, and unless the case has the desired hardness no matter how much care has been bestowed on the core the effort is wasted if the case is not hard enough to fill requirements. The essential principles of treating the case are identical with those involved in treating the core. The work is heated to the critical temperature of the case, which in open-hearth steel will be about 1400 to 1425 deg. Fahr., and this time it is quenched in fresh water, or where extreme hardness is desired it is quenched in brine. The lead pot is used extensively where the work must be free from scale, but work that is to be finish-ground all over can be very satisfactorily heated in the ordinary furnaces. It is always a good policy to run test pieces through with each lot so that there is some means of checking the results that are being obtained. The test piece should show at least 5 degrees deflection before a complete fracture is obtained. The fracture should show a soft core of a moleskin-like texture and the case should look like the fracture of a file or that of nicely hardened tool steel.

The same principles of heat treatment apply to alloy steels as they do for plain carbon steels. The only differences are that the critical temperatures of alloy steels vary somewhat from those of carbon steels, and it is the general rule that alloy steels will harden quite satisfactorily in a light quenching oil. This last feature has a strong tendency to minimize cracking during hardening. In every instance the up-to-date steelmakers can better determine what are the best temperatures at which to treat their respective brands, but no matter what the make of steel is, be it carbon or alloy the principles governing the case-hardening of it are the same the world over.

*The *Iron Age*.

An Electrically Conducting Paint

M. James describes a method of producing an electrically conducting paint by treating bronze paint with hydrochloric acid. Bronze powder does not conduct of itself, probably because each particle is covered with a film of oxide or fat. If a bronze paint is used containing equal parts of amyl acetate and acetone and 4 per cent of transparent celluloid, this can be made conducting by rubbing the slightly moist surface with strong HCl, or by exposing a freshly painted surface to fumes of HCl. A ready-made conducting paint can be obtained from bronze powder mixed with the amyl acetate solution. Concentrated HCl is added, and the mixture stirred till a paste is obtained. It is then washed with water, which is decanted; the paste is mixed with ethyl alcohol, the alcohol is decanted, and the residue mixed with the amyl acetate solution. The paint must be applied as soon as it is made, and a paint film of this kind has the appearance of gold-foil. Tests are described. The resistance of the film increases with time, owing to an unknown cause; if exposed to sunlight, the increase takes place somewhat rapidly, e. g., an increase of 200 per cent in four months is possible.—*Electrical World.*

Bird Houses*

Hints on Their Construction, Location and Care

By Ned Dearborn, Assistant U. S. Biologist

EACH spring before birds return from the South all filth and litter should be carefully removed from bird houses. In addition to the relics of previous occupancy, houses are likely to contain cocoons of insects and nests of bees or squirrels. Attention to this one item of spring cleaning is a substantial factor in attaching birds permanently to their houses. A little sulphur scattered about a house is a good remedy for parasites. When bluebirds or swallows take possession of a martin house it is a good plan to put up a one-room house in the vicinity and remove the nest from the martin house. Interlopers, thus evicted, often transfer their housekeeping to the small house. Houses designed for woodpeckers should always have an inch or so of sawdust in the bottom for

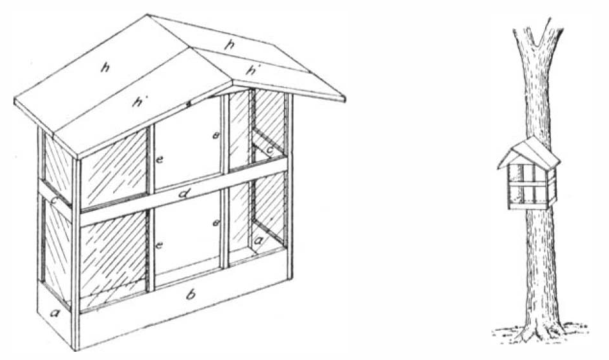


Fig. 1.—Food shelter for attachment to trunk of tree.

the reception of eggs, as woodpeckers do not gather nest materials. Due attention should be given to repairs. It is easier to keep houses in good order than to build new ones.

ENEMIES OF HOUSE BIRDS.

Birds have numerous enemies from which a careful landlord will try to guard them. Among these is the English sparrow, whose persistent attacks too often drive more desirable birds away from their nests and from the neighborhood. European starlings, which at present are not distributed beyond a narrow strip of the Atlantic Coast region centering about New York, are to be condemned for their pernicious interference with native house birds.

Cats and large snakes are enemies of birds, the former perhaps killing more birds than any other mammal. Trees and poles supporting houses should be sheathed with tin or galvanized iron to prevent these enemies from climbing to the nests. Squirrels give more or less trouble by gnawing houses, eating eggs and killing nestlings. Red squirrels in particular have a very bad reputation in this respect, and many experimenters keep their grounds free from them. Some regard flying squirrels as but little better than red ones. Even gray and fox squirrels are occasionally troublesome. It is not necessary, however, that bird lovers should wage indiscriminate warfare against all squirrels. It is far better to adopt the rule never to kill a squirrel unless there is reason to believe that it has acquired the habit of eating eggs of young birds; the result will probably be that not more than one red squirrel in fifty nor more than one gray squirrel in a hundred will have to be killed. Where squirrels are numerous they give more or less trouble by gnawing and disfiguring houses. This damage may be prevented, however, by covering the parts about the entrance with tin or zinc.

FOOD SHELTERS.

Another means of attracting birds about human habitations is to furnish an abundance of food, preferably in food shelters. If one is unable to make shelters that will protect food in all kinds of weather, the food may be fastened to trunks or branches of trees or scattered in sheltered places on the ground. A decided advantage in having shelters, aside from that of protecting food, is that they may be placed where the birds can be watched conveniently. When shelters are used the birds are first baited by placing food, such as suet, seeds, or cracked nuts, in a conspicuous place, and then led by degrees to enter the inclosure. Designs for two food shelters are exhibited in Figs. 1 and 5, one of which is supported by a post, the other by a tree. Structural details are shown for both. There is no bottom to either of them.

LOCATION OF HOUSES.

The location of a bird house or food shelter has much to do with its success, for the reason that birds have decided notions as to proper surroundings for a dwelling.

*From a *Bulletin* of the United States Bureau of Biological Survey.

Martins prefer to breed near houses, but not within 20 feet of trees or buildings. Bluebirds are inclined to select orchards or pastures having scattered trees. Wrens, thrashers, and catbirds live in thick shrubbery. Robins like trees with sturdy trunks and branches. Titmice, nuthatches, and most of the woodpeckers are woodland

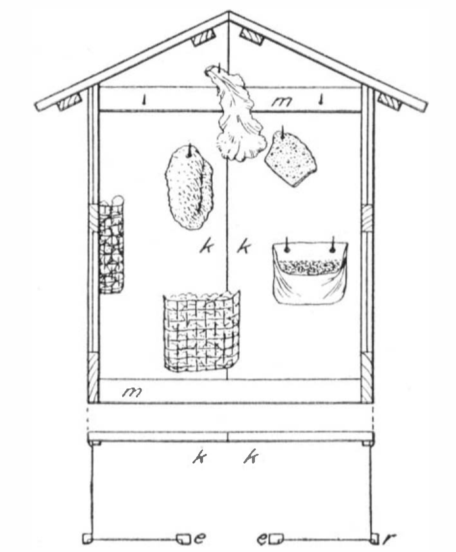


Fig. 2.—Vertical section, side to side, with suggestions for larder; diagrammatic and cross section of food shelter shown in Fig. 1.

species, although flickers and red-headed woodpeckers are more at home among the scattered trees of roadsides and pastures. Song sparrows frequent weedy swales and brush fences. Swallows do not enter woods so that a house would be as attractive to them in one open place as in another. The eastern phœbe, the black phœbe, and the house finch, while not limited to the haunts of man, are noticeably partial to them. Crested flycatchers, screech owls, barn owls, and sparrow hawks are governed more by convenience than by taste; although normally inclined to hold aloof from man, they have in many instances reared their broods in close proximity to dwellings. Barn owls, true to their name, accept suitable quarters in buildings without hesitation.

Before erecting bird houses one should first determine the kind of birds to which his premises are adapted. The question usually next arising is as to the number of birds that can be accommodated. Unless grounds are large, it is generally useless to expect as tenants more than

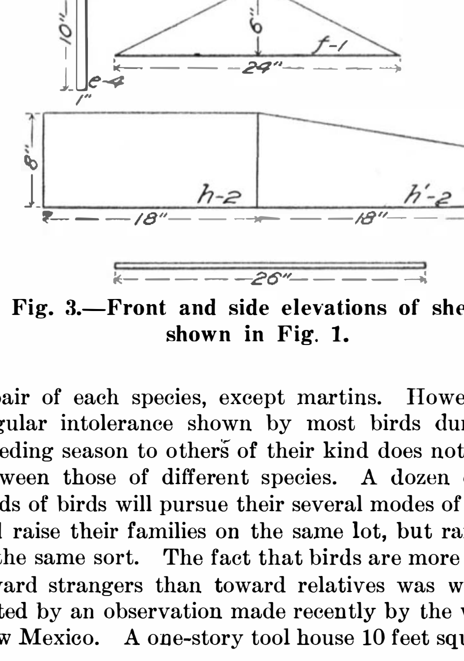


Fig. 3.—Front and side elevations of shelter shown in Fig. 1.

a pair of each species, except martins. However, the singular intolerance shown by most birds during the breeding season to others of their kind does not operate between those of different species. A dozen different kinds of birds will pursue their several modes of hunting and raise their families on the same lot, but rarely two of the same sort. The fact that birds are more tolerant toward strangers than toward relatives was well illustrated by an observation made recently by the writer in New Mexico. A one-story tool house 10 feet square had nailed to three corners of its roof rough bird houses made from packing boxes. One was occupied by violet-green swallows, another by western bluebirds, and the third by English sparrows. A still more remarkable association of different species has been reported by Otto Widmann, of St. Louis, Mo., who once had a pair each of flickers, martins, house wrens, and English sparrows nesting simultaneously in the same house. Of all our house birds, martins alone are social. The fact that there is a limit to the possible bird population on any given tract must be taken into consideration. When the probable tenants have been decided upon, the selection of sites is in order, for the site often decides the style of house that is to

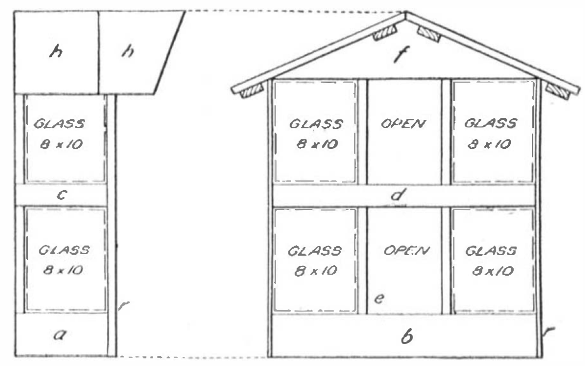


Fig. 4.—Lumber diagram of food shelter shown in Fig. 1.

occupy it. In the final placing of bird houses, care should be taken to have them face away from the winds prevailing in stormy weather. The strongly developed homing instincts of birds can be relied on to attach them to the neighborhood where they first saw the light, and the identical pairs which nest in the houses provided for them one year will often return the next season to enjoy the same bounty and protection.

The Preparation of Surgical Catgut

THE fact that catgut is absorbed within the body makes it invaluable to the surgeon for making sutures of operative wounds. Unfortunately its origin makes it somewhat difficult to manufacture it in a perfectly sterile condition by ordinary commercial methods. In spite of subsequent sterilization at the hands of the surgeon it frequently happens that some taint lingers and causes a secondary infection of wounds. The European war, of course, has enormously increased the demand for surgical catgut, and the vital importance of having it certainly sterile has induced a French scientist, Prof. Goris, of the School of Pharmacy, to undertake a series of experiments to determine the best method of obtaining it.

Catgut is prepared from the small intestine of the sheep. The ordinary process of professional gut-workers is as follows: The gut is emptied, roughly scraped with a special instrument, then split longitudinally into two halves. These are macerated in alkaline solutions, and the interior mucous membrane is then very carefully scraped. The gut is then sometimes treated with oxygenated water and sulphurous acid to bleach it. The thongs thus obtained, united in bunches of two, three, four or five, are twisted by means of a sort of rope-maker's wheel. The resulting cords then undergo a series of pharmaceutical treatments to render them sterile, and are then known as catgut; this is delivered in closed tubes. Of all these operations that of the final sterilization is most difficult, and as we have indicated, it is not always successful in case the gut was infected before being twisted.

Prof. Goris, whose researches were conducted at the Pasteur Institute, reports his conclusions in the January number of the *Annales de l'Institut Pasteur*. He states positively that the preparation of firm and sterile catgut depends more on the manufacture of the cord than on subsequent sterilization of the finished product. If the cord be prepared according to the laws of bacterial asepsis, and carefully preserved from reinfection by contact, it is easy to get a sterile product; but if the cord is infected sterilization is difficult, and almost impossible. He therefore advises that the cords be twisted from aseptic thongs, and that their preparation be in the hands of responsible pharmacists. In default of this, gut-workers should be required to follow a prescribed formula. The intestines should be removed as soon as the animal is slaughtered and im-

mediately placed in portable ice-boxes, so that they may be transported under the best conditions to the workshop. They should receive the preliminary treatment the same day and the thongs or strips of gut placed at once in antiseptic solutions in order to suppress the unnecessary fermentation which they undergo ordinarily. A complete sterilization ought to be obtained by leaving them for forty-eight hours in 50% oxygenated water. As soon as this is done it is indispensable that they should be removed to an entirely different place from that where the scraping was done. The manipulation (spinning and twisting) must be performed by special operatives and on a substance which is imputrescible and easy to disinfect, for it is precisely in the course of these manipulations that the cords are most easily reinfected. Hence, it is this part of the work which demands the closest surveillance. Mr. Goris recommends any one of four methods tested by him for sterilization:

1. Imersion for forty-eight hours in a 0.5% to 1% solution of iodine.
2. Immersion for seven or eight days in eucalyptol.
3. Tyndallization in 90% alcohol at 60 deg. Cent. for ten hours per day for five days.
4. Heating to 120 deg. Cent. in anhydrous liquids or vapors—absolute alcohol by preference.

For infected cords these limits of disinfection must be considerably extended, and well-protected and resistant spaces may even then escape. Catgut thus prepared may be transported in a properly chosen sterile liquid of a kind to render it pliant. The author advises alcohol or acetone containing 20% to 25% of water, and if need be 5% to 10% of glycerine. The preferable choice would certainly be bouillon of guaranteed sterility, but though this was advised by Répin more than twenty years ago, many surgeons remain still prejudiced against its use.

The Economic Possibilities of the Danube as a Cosmopolitan Highway

On both sides of the great conflict the minds of partisans are turning more and more to the consideration of the laws and regulations which shall govern international trade and traffic when the great war is ended.

Both the Central Empires and the Allied Powers are seriously discussing what may be described as economic warfare to the knife, with policies of "favored nation" agreements between friends and prohibitive tariffs to former enemies. Without entering into the merits and dangers of such policy, which many impartial economists consider fatally unsound, it is of interest to learn something of the processes by which the opponents concerned count on gaining their ends. Much light is thrown on German ambitions by a discourse recently delivered in Munich under the auspices of the Hansabund.

The speaker was Privy Councilor Dr. Günther and the title of his address was "The Danube as an Economic Highway of the Future." It was reported in the Proceedings of the Bavarian Canal League, and we quote from an abstract of this report appearing in *Glasers Annalen für Gewerbe und Baukunst*. After speaking of his memories of nearly nineteen years ago, in reference to the opening of the Iron Gate to ship traffic, Dr. Günther spoke as follows:

Not merely a cosmopolitan commercial highway, but a cosmopolitan economic highway must the Danube become. It would have probably become the first even in times of peace if all the border states had co-operated in their own interest to clear away the still existent obstacles. Indeed, considerable beginnings with this end in view had already been made. But now something greater and more valuable must and shall spring from the tremendous world conflagration in whose midst we still find ourselves.

We see before our eyes the outlines of a new group of states which will embrace Central and Southeast Europe at first, but ought to prove also a powerful center of attraction for the northern Germanic states, and perhaps also for many nations who now stand opposed to us in hostility and hate. To the idea "Middle Europe" Naumann has given a new and far-seeing conception, as did "Deutschlands Friedrich List" before him. A victorious and honorable ending of the war will show forth the justification of this conception even in the eyes of all those who doubt.

Huge economic possibilities will then be opened up, bearing in their train the necessity of creating new methods for the exchange of goods which will far exceed those which have hitherto served us. Goods which require rapid forwarding to their destination can be sent back and forth over the now nearly completed railroad line of Antwerp-Berlin-Vienna-Constantinople-Bagdad from the ports of the Atlantic to those of the Indian Ocean. For heavy freight, in whose delivery time is not an important factor, safe and cheap rates can be secured by a sound policy with regard to interior waterways—a policy which shall discard all old-fashioned considerations.

But the right of the Danube to its position of im-

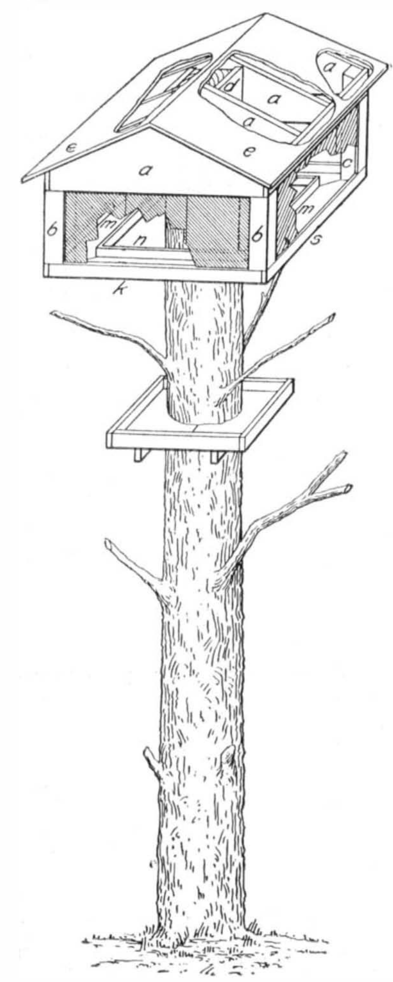


Fig. 5.—Food shelter for attachment to post. Roof cut away to show construction. Sides made of glass; size of panes 8 by 10 inches.

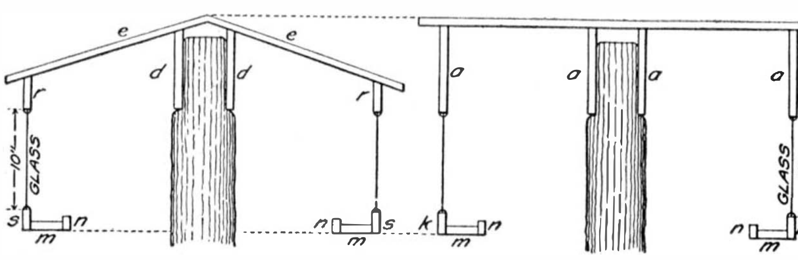


Fig. 6.—Cross and longitudinal section of food house shown in Fig. 5.

portance in these concerns was preordained in the gray mists of by-gone geologic eras when this great collective artery was just formed by the junction of countless minor streams. Industry will make eager use of the

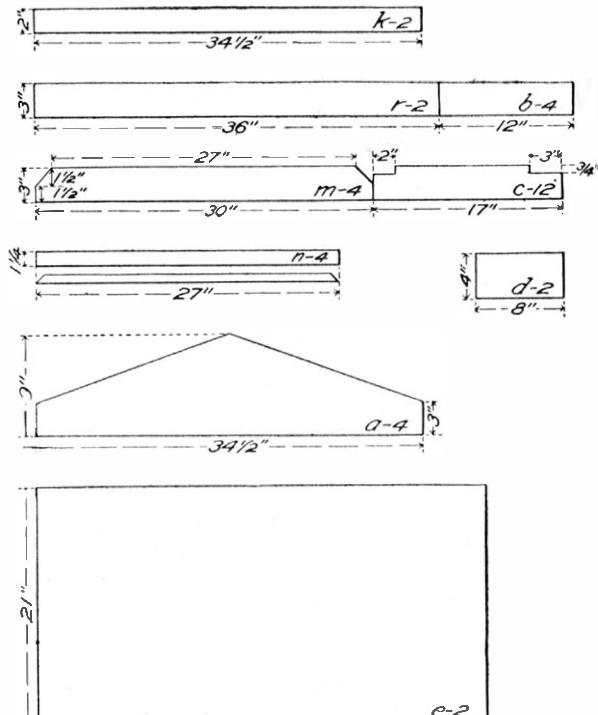


Fig. 7.—Lumber diagrams of food shelter shown in Fig. 5.

new paths opened before it, and what was at first merely an economic highway of Europe will in time come to serve the needs of all civilized humanity, precisely like the great canal systems in the Old World and the New.

Our Danube has already played a similar rôle of old in lesser degree, naturally. This was a thousand years ago and more, when there was no America and no sea road to the Orient. At that time this waterway formed the obvious connecting link between the West and the Byzantinian East. At that time Regensburg was one of the chief commercial cities of our part of the earth and held a position in the world commerce to which it is now slowly beginning to climb anew, thanks to a series of measures instituted by the state of Bavaria.

And though the rivalry of the Italian commercial republics gradually began to be overwhelming, yet for many centuries more the Danube remained a lively road of intercourse whose qualities were shared by the adjacent navigable streams. The Inn, at least in its lower stretches below Wasserburg, was a populous stream on which in the time of the war with the Turks men and wares made their way to the Danube, and thence on the latter to the seat of war. Throughout many generations endeavors were made to improve the many unfavorable conditions; the names of Maria Teresa and Joseph II. are indissolubly connected with the extensive labors with regard to "Strubel" and "Wirbel."

And again, as late as 1896, efforts were made for the regulation of the Iron Gate, when the river, rushing from the narrow passage of Kazan, is interrupted by half invisible rows of cliffs. From there on, however, the evil conditions of the flatland stream begin to make themselves felt: backwater, inundations, irregularities of the channel, and mud banks. Thus two of the three mouths became unusable, and only the middle one, that of Salina, has been kept in a passable condition by the activity of the European Danube Commission, which has been in charge of the work since 1856. All this must be conceived on bigger lines and pursued more energetically when once a new era commences and Roumania begins to see her advantage clearly.

Moreover, the Delta is now relieved by means of the highly important railroad Tschernawoda-Constanza, to which the longest railroad bridge in Europe belongs. Indeed, in our age of engineering technique, the canal project by way of the Dobiudscha, recognized as unfeasible in 1835, no longer seems a fantastic scheme.

But hand in hand with the final regulation of the main stream, which will then probably soon carry a greater number of steamers and towboats, there must go a new orientation of the canal system in the interior of Germany.

There was a time when it might be said that the railroads had finally forced the water roads into the background; in the future both modes of conquering distance will be of equal importance. After two decades the King of Bavaria and the Bavarian Canal League have finally seen accomplished the results of their untiring efforts at a timely development of the idea of Charlemagne.

No longer upon our narrow fatherland alone . . . is laid the honorable obligation of solving this world problem. The whole empire must share the task of placing Bavaria, as the intervening land between the waters flowing to the North Sea and the sole tributary of the Black Sea, in the position it deserves—corresponding to its geographical position—of being one of the most important links in the chain of world commerce spanning our continent.

As recently as two years ago the grounds of this conclusion would have been denominated an illusion, as untrustworthy "music of the future." Even to-day there may still be Philistines who hold these ideas to be chimerical, just as eighty years ago the uniting of Nürnberg and Fürth was declared a sheer impossibility.

However, the great teacher, War, who has showed us so many things in a new light, will not fail to display his pedagogical effectiveness in the present case; and those who come after us old fellows will live to see accomplished the enterprise that will make for all time Germany, and with her Bavaria, a new rivet in the chain of the European peoples and states.

A Mica X-Ray Spectrometer

An interesting spectrometer for the study of X-rays, using mica as an analyzer, has been used by several investigators. This spectrometer consists essentially of a sheet of mica, bent to a cylindrical shape, on which a beam of X-ray falls. The various components of the beam are reflected at different angles and are received on a photographic plate. In the instrument used in the present work a beam having an angle of 5½ degrees allows a range of 45½ degrees in the angles of reflection.

The Determination of the Resistance of Ships*

A Review of Recent Investigations Relating to Powering Different Types of Vessels

By Ernest H. Rigg, Esq.

When it was suggested to me that a continuation and extension of the paper I had the honor of reading before the society in 1912 on "Fuel Economy as Influenced by Ship Design" would be interesting and of value, I quite recognized the interest and value of further light on this increasingly important subject, and in reply stated that I feared such a paper would contain very little original matter, but that if the society would like to have placed in its transactions a review of recent-published investigations, together with a review of our present knowledge on the subject of powering ships, I should be glad to undertake the task. Such a review can be made of decided value, the transactions thereby becoming so much more useful to those who design and power ships. This, then, is the object of the paper.

The subject naturally divides itself into two parts of primary importance, one concerning fine types of ships, and one concerning full types; where the line between the two should be drawn is by no means clearly defined, but, in practice, warships and passenger liners constitute the fine types and cargo steamers the full, with, of course, some exceptions to be found both ways. Motor boats, submarines, and hydroplanes are now the subjects of increasing investigation; the usefulness of the two latter types in the great war insures a measure of attention hitherto given only to the larger naval vessels. Published data are already assuming considerable dimensions, but there remains, however, plenty to occupy the staffs of the various experimental tanks the world over.

This paper will deal more particularly with general naval and mercantile types. One of the first things that strikes the reader of the various authorities on this subject is the desirability of a uniform system of notation throughout the technical world. Anyone who can do something to bring this about will have earned the gratitude of all naval architects and naval engineers.

The lucidity of Taylor's "Manual of Marine Propulsion" stands out as one of the chief merits of the book, practically all fundamental points being covered.

American writers generally follow the same lines, but, when we read recent and valuable papers written abroad, we naturally find different systems of notation in use. There is, in practice, danger of serious error in using first one reference and then another, besides the labor of reduction of results from one system to the other, so that anything tending toward an international standard is well worth encouragment and advancement.

In recent years marked reductions in the power necessary to drive a given weight of ship and cargo at a given speed have been made; the experimental tanks are justly proud of the cuts they have been able to make in the power for models submitted to them for test. They are the people best placed to keep in touch with developments so far as smooth-water results are concerned and are now producing tangible results for merchant ships of all types as well as for warships, both here and abroad.

In 1912 the author read a paper before the society which pointed out several instances of saving due to experimentation; before and since then much has been written and something has been done to keep down coal bills. At the Franklin Institute, Philadelphia, in the same year, I ventured to suggest that the saving in coal made by the naval architect might well be handed back to him in part to provide extra subdivision and stability for passenger ships—by no means a bad reply to the question of extra first cost of additional beam and bulkheads—so that the passenger need never really know any material difference in the price of his ticket due to increased first cost of ship.

The efforts connected with twin-screw drives for full cargo ships, both steam and motor driven, have recently shown some unusually good results. Recent colliers built for the navy are cases in point, and their trials and service results are of particular value in all similar twin-screw vessel design, steam or motor.

In recent years a strong tendency to conduct systematic experiments on ship resistance is noticeable, and for this we cannot be too grateful. Isolated pullings of models as submitted are necessary, but it is only when the lessons drawn from these experiments are followed by systematic research that the profession as a whole begins to derive benefit from the work done. We have passed from the stage of individual and disconnected experiments to that of systematic research directed along lines that are already having a noticeably marked effect in reducing power or increasing speed in shipping generally.

It should also be remembered that model experiments are only half the battle; they must be followed by a progressive trial on the measured mile in order that the design of the propellers may be verified and the performance of the machinery properly noted. This trial should be conducted at the same trim and draught as the model was towed, and this should be as near the working-load draught as possible and deep enough to give proper immersion to the screws. It will not always be easy for builders to arrange for the loading of the ship, except in the case of oil tankers; but this can generally be managed at the expense of a few hours' delay to one voyage after the vessel is in service, once the owners realize the savings that are at stake.

At the time (1910) of the publication of Admiral D. W. Taylor's manual the literature of this subject was beginning to assume good proportions. It was, however, scattered, and the naval architect who did not keep in touch with a good many sources of information was at a serious disadvantage. This book brought together the best collection and arrangement of experimental data that we have.

It can safely be said that this book marks an epoch in the methods in practical use for designing and powering ships. Shipbuilders and owners are now fully alive to the value of the tank and are keen to take advantage of all it can teach them, to their no small benefit in coal bills and better service.

Since beginning this paper—in fact, very near the ending of it—Mr. G. S. Baker's new work on ship propulsion has become available in this country. Mr. Baker summarized the present status of tank work and our knowledge of this whole subject in a very able and clear manner. He uses, in the main, the "constant" system of notation, which is perhaps not as much used on this side of the Atlantic as on the other, and his book is a most valuable contribution to the literature on the subject, the main results of recent experimentation being carefully gathered together and presented in one volume, very much my own purpose in writing this paper. As in much other recently-published matter, the full-cargo ship receives considerable attention in Mr. Baker's book.

The chapter on canal towage contains information not generally available in such useful form. These two books set forth our knowledge on the subject so clearly and well that the question may be asked as to the necessity of quoting at length the papers, etc., listed at close of this paper. To study the steps leading up to their production and the work done by these and other investigators will repay the men responsible for the dimensions and lines of our ships, both naval and mercantile. It is largely in the hope that our younger members will be helped in their researches by this brief review of present-day knowledge that this paper has been prepared. The author is well aware that no new discoveries are set forth herein, but trusts that, in spite of that fact, the science of ship propulsion will be benefited by this addition to our transactions.

It will be noted that this paper only covers the literature of our own language on this subject. At first sight this appears unfortunate, and there are, doubtless, many undiscovered gems of knowledge tucked away in foreign works. In the main, however, the work of foreign investigators is summarized in the books and papers listed, and as the same are there acknowledged, no injustice is done the men whose work is thus only indirectly referred to.

The society was founded in 1893 and the 1915 volume will be No. 23. In searching for papers it frequently happens that much time is lost through lack of a comprehensive index, therefore I would strongly urge that the *Transactions* be indexed, such index to be sold to members at cost price. It would be necessary to keep the index up to date, but if the work were kept up each year to prevent undue accumulation, supplementary indices could be issued every 3 or 4 years and the whole combined every 10 years or so, or as the stock of the main index was exhausted.

It has been with considerable regret that I have avoided extending this paper to cover, in a similar manner, the literature of the screw propeller. It would have been impossible to adequately cover both of these branches of the subject in the time at my disposal, and I would suggest that a corresponding paper on the propeller side of the question be prepared for next year, if the council consider it worth while.

A few paragraphs follow in which matters of current interest in ship propulsion are touched on together with a list of references which contain practically all that has been published of late years on this subject.

EFFECT OF INCREASED BEAM.

It has long been known, and acted upon, that large beam, generally speaking, involved high resistance; we realize nowadays that too high a price can be paid for small beam and resistance. Increase of beam, accompanied by increase of stability and decrease of fullness, by no means necessarily spells increase of power; for the same or less power a healthier type of vessel can generally be obtained, at, however, a somewhat increased first cost of hull material in most cases, due to increased wetted surface and wider decks.

We have arrived at a point where increased safety is demanded in passenger carrying vessels; it is no use putting in bulkheads to enable a ship to keep afloat after damage if the other danger—loss due to lack of stability in the damaged condition—is not also provided for. Loss of buoyancy and loss of stability must both positively be kept in mind when settling on dimensions in a given case.

The effect of this on speed and power will by no means be proportional to the increased beam, as might appear at first sight. A far worse enemy to good driving is full waterlines in the forebody. In two recent cases of relatively fine and fast ships that have come directly under my notice, the forward waterlines were forced out by considerations of stability to the point of a marked decrease in speed when compared with similar ships in the same principal dimensions and power. This feature, also, has its limitations, for in full and slow cargo boats the exact opposite is true below a certain speed. This condition is brought out by Prof. Sadler in his 1909 T. S. N. A. paper and was verified in a recent case by direct experiment for a vessel about to be laid down. While this is true for smooth water there remains the question of loss of speed in head sea. This question has recently received considerable attention and is referred to elsewhere in this paper.

It is safe to say that passenger ships generally will show a tendency to increased beam in the future, extra life-saving equipment, the natural desire of passengers for deck cabins and extra stability for damaged condition all tending the same way. This will not necessarily entail more power, because we know more about good forms and because ships are tending to be somewhat finer to give better sea performances. The cruiser stern is another way out of this difficulty.

The British Board of Trade's recent instructions to steamers in the danger zone throw an interesting light on this point, applicable almost as much to peace as to war damage: "In order to prevent the vessel taking a sudden list if holed by a torpedo, the stability should be increased to the utmost extent practicable by filling ballast tanks or otherwise."

Another paragraph follows, relating to longitudinally bulkheaded ships of small initial stability; both these paragraphs point toward increased beam. The same reasoning points to increased beam in our line of battleships; for a 31,500-ton ship, a beam of 110 feet is already responsibly suggested abroad, and the paper by General Goulaeff before the London Institution in 1908 is well worth looking up, in the light of recent happenings. Who knows but that battleships laid down abroad since the war began are not of this largely-increased beam! It is probable that less weight will be available for machinery, owing to increased protective weights; and that this, together with the new proportions, will mean a decrease in speed. The beam to draught ratio is about 3.25 in recent battleship designs, whereas in the 110-foot ship mentioned above it goes up to 4.40. In this connection, the speed curves given by General Goulaeff are of interest. The Yorktown experiments quoted by Admiral Taylor in his manual indicate an approximate increase in power of about 11 per cent for the same speed for battleships of this displacement and with proportions varying as above.

EFFECT OF WIND AND SEA.

A good smooth-water performance is not necessarily a good sea performance; considerable attention has recently been given to this question and some interesting facts brought to light. There was the hollow versus straight lines discussion in the London Institution, 1905 (Vol. 47); Admiral Taylor referring briefly to the question in his new manual on speed and power (p. 121). Baker in his new book also discusses this point.

* From a paper read before the Society of Naval Architects and Marine Engineers.

Early this year Sir A. Denny referred to the matter before the Institute of Marine Engineers, citing instances of improvement in sea performance due to decrease in fullness compared with previously accepted practice. His point was that low first cost and low operating costs did not always go hand in hand.

Mr. A. Hamilton in 1911, before the Liverpool Engineering Society, gave data based on the comparative performances of ships of varying fullness, all tending to show that the somewhat finer vessel (particularly forward) more than balanced the loss in dead weight per trip by an increased number of trips per year.

It is difficult to deduce any rule, but the general lines to follow are obvious—the speed curves of a design should be run well up beyond the designed speed and attention given to the characteristics of the curves at the speeds beyond the smooth-water maximum as well as at that miximum. It may often be that an apparent sacrifice at normal speed is no sacrifice at all, but really a decided gain in coal burned per annum in a seagoing ship, particularly a transoceanic or great coastwise trader. A paper by E. S. White before the Northeast Coast Institution (1912) is well worthy of study in this connection.

EFFECT OF SHOAL WATER.

This subject has come to the front recently in practice as well as in theory. Torpedo-boat destroyers have furnished the most interesting cases, and the subject is worth very serious consideration by those responsible for the performance of vessels running in shoal bays, rivers and lakes. The literature on the subject gradually accumulates and we are now in possession of a very considerable amount.

Admiral Taylor refers extensively to the subject in his manual, the historical data therein gives credit to the earlier investigators; and numerous references will be found in the bibliography of this paper.

It is not too much to say that knowledge of the effects, both bad and good, of shoal water is absolutely necessary to the proper running of destroyer trials, and no less so for the designing of shoal-water vessels. It will pay those charged with running big-vessel trials to be very careful where they run them.

On a recent trial of a 400-foot vessel drawing 19 feet and of 15 knots' speed, the performance at sea in smooth water was materially better than on the measured course, due to deeper water as well as to the absence of the necessity for frequently turning to run over the course; the reduction in horsepower being about 4 per cent.

In a destroyer trial at 24 knots it was found that in 15 fathoms the power required to maintain standard revolutions was materially higher than on standardization and that on going off into deep water this at once changed.

Besides the guidance to be obtained from Taylor's Manual, his T. S. N. A. paper of 1913 on relative resistance of models with constant block and other co-efficients varied contains valuable data. Baker's new book has a chapter devoted to shoal and restricted waterways that is extremely useful. Canals are an important part of shoal-water navigation, and the value of special consideration was emphasized before the Royal Society of Edinburgh as far back as 1840. Much work has been done before and since, especially in connection with the navigation of French, British, German and Dutch canals.

The navigation of the Nile and similar rivers has received special consideration for centuries.

Prof. Sadler has carried out valuable experiments at the University of Michigan; his 1911 T. S. N. A. paper giving information on merchant-ship forms being worthy of careful study.

Hudson River boats have received, to their no small benefit, special consideration from the point of view of bank erosion as power saving, if it is possible to separate the two as far as rivers of moderate breadth are concerned.

CRUISER STERNS.

Of late years an increasing number of merchant vessels have been built with the form of stern considered peculiar to battleships and cruisers.

There is much to be said in their favor and the effect on speed may well be noted here; for a given overall length this stern gives the maximum mean immersed length and a resulting decrease in power and consequently machinery weight, necessary for a given speed, varying with the size of the ship, being greater in the smaller ship. The adoption of this stern is attended with increase in stability, in deck room, and in protection to screws in harbor.

The chief objection is increased first cost, appearance is another in some eyes, but small increased first cost will have a hard struggle against a possible 8 per cent saving in coal bills. The arguments are very much in favor of the cruiser stern for all twin or more screw designs, with a good chance in the single-screw design providing the draught is large.

Modified cruiser sterns are common in our waters for ships that do a large amount of warping into and out of docks, notably in the Chesapeake Bay and similar waters; also on the coast in a few cases, some Old Dominion liners being built that way. Doubtless many other instances could be found.

EFFECT OF TEMPERATURE ON RESISTANCE.

It has been known for some time in the experimental tanks, that temperature plays a part in ship resistance.

Messrs. Denny Brothers, Dumbarton, are reported to have been unable to account for differences in Summer and Winter trials of sister ships in any other way, and the matter is also under investigation at the Teddington tank in England.

Differences in resistance as high as 4 per cent per 10 degrees difference in temperature are reported, the lesser resistance corresponding to the higher temperature.

APPENDAGE RESISTANCE.

Lately this has received renewed attention; since Taylor's experiments in the Washington tank, showing the run of the stream lines on ship models, designers have studied more carefully the placing of bilge and docking keels.

Sadler's experiments on enclosed shaft bossings have also given valuable aid in properly placing these appendages. The author recalls a large vessel which had her bossing altered to better form, with the result that the speed at constant displacement went up from 18 to 18½ knots. This increase in a vessel displacing over 11,000 tons was due solely to a change in the lines of the bossing.

In battleships appendage resistance as high as 25 per cent of the total have been recorded. The importance of reducing this where practicable is at once evident.

For more detailed information the reader is referred to Taylor's Manual and to Dyson's work on screw propellers.

No important vessel should be laid down without stream line diagrams at critical speeds.

The fitting of anti-rolling tanks has a small and indirect effect on resistance. The result of omitting bilge keels is a saving of about 3 per cent, which is cut in half by the extra displacement due to weight of the tanks and contained water; this saving should help to pay for the tanks and controlling gear. Anti-rolling tanks, however, undoubtedly require skilled handling and constant watching while at sea.

References to bilge keel and other appendage resistances will be found in the bibliography.

Baker has an interesting chapter on appendages in his book just published.

The importance of an allowance for air resistance should not be overlooked.

SUMMARY.

To sum up briefly the above notes, suggestions and recommendations, the following may be said:

The system of notation used by Taylor and Sadler in presenting their results is ample, clear and direct; it is, therefore, preferable for general use.

The model of practically every naval or passenger design should be tested in the tank and enough models of cargo vessels similarly tested to cover a useful range of vessels, so that each yard can know whether their "lines" are good and make improvements from time to time as experience points out. This is the only real way "lines" can be compared and improved, for trial conditions vary all the time and service conditions and results are seldom accessible to builders except in a very general way. In this connection the relative smooth and rough-water performances should be kept in mind.

For large cargo ships, and practically all motor ships, a twin-screw drive is the most efficient; the 2, 3 and 4-screw drive is so well established in passenger and war ships as to need no further comment. Further light is desirable on vibration problems, especially for vessels with machinery aft. Speed and stability are intimately associated and generally pull at cross purposes; the temptation to small beam, high speed, and comfort at sea for passengers may be yielded at the price of safety in accident.

We are at present witnessing the passing of the very full cargo ship at sea in favor of a somewhat finer type. This is a good step. Cruiser sterns for twin or triple-screw ships are decidedly to be preferred to the old type of counter. Appendage resistance is generally very small in single-screw merchant ships, but cannot be watched too carefully in other and faster types. Enclosed shaft bossings are generally preferable to open brackets.

We are not yet ready to advocate the general adoption of anti-rolling tanks. Progressive trials of important ships should always be made and enough cargo ships thus tried in load condition to check up model tank and propeller performances. This could well be emphasized toward oil tankers, on account of the ease with which they can be loaded; other types of ships of similar lines would thus also benefit.

Plasticity and Viscosity

Plastic flow is of importance in many diverse fields, such as geophysics, colloidal chemistry, metallurgy, ceramics, road building, and the lime and cement business. The property of plasticity, like ductility and malleability, is not at present strictly definable, although the term is much more familiar and generally known than the strictly defined terms "vicosity" and "fluidity."

In the study of plastic flow it has already been shown that most homogeneous solids will flow somewhat after the manner of liquids, if subjected to sufficient pressure. Copper, steel, lead, ice, menthol, glass and asphalt fall in this class in so far as they may be regarded as homogeneous solids. But ordinarily plastic substances are not homogeneous solids but suspensions of finely divided solids in fluids, such as paint in oil, lime in water and especially clay in water. Numerous papers have been devoted to the explanation of this latter type of plasticity.

Since glass and other similar bodies are often regarded not as solids but as very viscous liquids, the demarkations of viscous flow from plastic flow has not been sharply made. In fact, attempts have been made to give numerical values to the viscosity of ice, menthol, glass and pitch, and Tammann[1] defines plasticity in a perfectly definite manner as the reciprocal of viscosity —in other words, plasticity and fluidity are synonymous.

Unfortunately, for the sake of simplicity, this definition is clearly untenable. If any finely divided solid, such as clay, be suspended in a liquid, the fluidity is lowered rapidly and in a perfectly linear manner, so that at a comparatively low concentration of clay the fluidity, as measured in the ordinary viscometer, approaches zero. Thus Durham and Bingham[2] found that a certain clay suspended in water gave a zero fluidity when the volume percentage had reached 6.95 (14.6 per cent by weight), this being independent of the temperature. This concentration apparently serves to sharply demarkate plastic from viscous flow. Suspensions more dilute than this critical concentration are subject to viscous flow, while those containing more solid in suspension are plastic.

These results are in harmony with the views of Maxwell,[3] which are so important that we quote them at length:

"If the form of the body is found to be permanently altered when the stress exceeds a *certain* value, the body is said to be soft or plastic and the state of the body when the alteration is just going to take place is called the limit of perfect elasticity. If the stress, when it is maintained constant, causes a strain or displacement in the body which increases continually with the time, the substance is said to be viscous. When this continuous alteration of form is only produced by stresses exceeding a certain value, the substance is called a solid, however soft it may be. When the very smallest stress, if continued long enough, will cause a constantly increasing change of form, the body must be regarded as a viscous fluid, however hard it may be.

"Thus a tallow candle is much softer than a stick of sealing wax; but if the candle and the stick of sealing wax are laid horizontally between two supports, the sealing wax will in a few weeks in summer bend with its own weight, while the candle remains straight. The candle is therefore a soft (or plastic) solid, and the sealing wax a very viscous fluid.

"What is required to alter the form of a soft solid is sufficient force, and this, when applied, produces its effect at once. In the case of a viscous fluid it is time which is required, and if enough time is given the very smallest force will produce a sensible effect, such as would be produced by a very large force if suddenly applied.

"Thus a block of pitch may be so hard that you can not make a dint in it with your knuckles; and yet it positively will, in the course of time, flatten itself out by its own weight and glide down hill like a stream of water."

The experiments of Bingham and Durham support the definition by Maxwell that a plastic body is one in which the form of the body is found to be permanently altered when the stress exceeds a certain value. These experiments indicate that the demarkation between the two *régimes* is very sharp, but they do not give any clue in regard to the laws of plastic flow, which must, therefore, be known before a rational basis can be obtained for the quantitative measurement of plasticity.—*From Scientific Paper, No. 278, of the Bureau of Standards, on "An Investigation of the Laws of Plastic Flow," by Eugene C. Bingham.*

[1] *Ann. der Phys.*, 7, p. 198; 1902.
[2] *Am. Chem. Jour.*, 46, p. 278; 1911.
[3] Theory of Heat.

X-Rays and the Theory of Radiation

CONSIDERING that the theory of radiation has been the foremost fundamental problem of late years, while X-rays are becoming more and more a general weapon of experimental research, it may appear a little surprising that Prof. C. G. Barkla, F.R.S., of Edinburgh, in introducing his Bakerian Lecture on "X-Rays and the Theory of Radiation,"[1] should have remarked that discussions on the electro-magnetic theory of radiation did not give full consideration to X-rays. Many scientists at present incline to a certain modification of the theory. Prof. Barkla, to whom science owes the remarkable discovery of characteristic X-rays, rejects the suggestion of a modification; he does not believe that radiation energy is emitted and absorbed in definite, indivisible quanta; to him the phenomena become meaningless on the suggestion of a quantum or entity of radiation. Prof. Barkla is, however, prepared to accept the quantum theory in a sense, rather as one of atomic energy than as a quantum theory of radiation. We will attempt to give a brief summary of his views as expounded in the Bakerian lecture and also in the Royal Institution discourse. Broadly speaking, the problems of radiation are problems of electrons and atoms. Negatively charged corpuscles (electrons), Prof. Barkla pointed out, were emitted by matter when exposed to heat, cathode-ray bombardment and other conditions; but there was an analogous emission of positive particles under the same conditions, except with radio-active substances whose positive particles were atoms of helium. The electrons were studied by their magnetic deflection and by the ionization which was directly produced by them and indirectly by the X-rays. The energy of X-rays of differing wave-lengths might be compared by measuring the total ionizing power. In his Bakerian lecture Prof. Barkla considered the X-ray emission under three heads: as scattered X-radiation, as fluorescent (characteristic) X-radiation, and as primary X-radiation. We should almost prefer to begin with the last of the three; but as there was little time left in the lecture for the third head, we will follow Prof. Barkla's sequence.

Scattering, he said, was the process of re-emission of secondary radiation by matter on which primary radiation fell. Experiments on the quality, polarization and distribution of the scattered radiation showed that it was emitted by electrons whose motion—that part which resulted in radiation—was completely controlled by the primary radiation; long-wave primary rays gave long-wave secondary waves, etc. The intensity of the scattered radiation was greatest in the direction (both forward and backward) of the ray, and depended simply upon the mass of the atom, not upon the primary wave-length, while the number of electrons in an atom was simply a function of the atomic weight. According to Sir J. J. Thomson, the intensity of scattering in air was given by the formula $\frac{8\pi}{3} \cdot Ne^4/m^2$, where N was the number of electrons, e their charge, and m the mass. The number of molecules contained in a cubic centimeter of air was 2.75×10^{19}, and in his (the lecturer's) early calculations the number of electrons had come out hundreds of times greater than that product. Very careful later measurements proved, however, that the number of electrons was always equal to half the atomic weight, so that the carbon atom contained 6, the nitrogen atom 7, the oxygen atom 8 electrons, and so on; hydrogen (atomic weight 1) was an exception to the rule, for it had one electron per atom. J. J. Thomson had suggested that the electrons were distributed in a uniform field of positive electricity. From the scattering of a particles Rutherford had concluded that the positive electricity must be concentrated in a small central nucleus, about which the electrons revolved in rings; and Bohr and Moseley had extended this view in order to account for the lines of the spectrum, the hydrogen lines of the Balmer series in the first instance. In order to explain all the properties of hydrogen by the assumption of one electron revolving about the nucleus, Bohr had suggested that the hydrogen atoms differed from one another as to the orbits of their electrons; if the radius of one hydrogen atom (distance of the electron from the nucleus) was 1, it would be 4, 9, etc., for others. Prof. Barkla could not understand that. In his opinion, X-rays traveling over matter disturbed every electron, and X-rays produced in the lecture theater would, for instance, cause every electron in the bodies of his audience to tremble. Groups of atoms, and even atoms—not merely individual electrons—were concerned in X-radiation, and the whole deduction strongly supported the adequacy of an unmodified theory of electro-magnetic radiation by transverse rays.

These arguments were strengthened by the consideration of the fluorescent (characteristic) X-radiation, which could only be excited by a radiation of shorter wave-lengths—i. e., of higher frequency—than the fluorescent radiation which was characteristic for each element. The intensity of these characteristic rays was uniform in all directions (the curve being a circle, not a kind of ellipse, as with scattered rays); there was no polarization, and the characteristic rays were not controlled by the primary; in fact, they arose only indirectly from the primary beam, and its emission was only an accompaniment of an exceptional disturbance, which was probably of the nature of the ejection of a high-speed electron. The intensity was independent of the speed of ejection and of the career of the electron after its ejection; the radiation did not arise outside the parent atom, and the origin of the radiation was really in the atom. The further study of the relation between the fluorescent radiation, the corpuscular radiation, and the special absorption of the primary beam threw light on the process. An element might give rise to several characteristic radiations distinguished as belonging to the K and L series, the K being of higher frequency and harder than the L. Recent studies of carbon, nitrogen, aluminium and sulphur suggested the further existence of a still harder series, J, and possibly also of softer series, M, N, etc. When E was the total energy absorbed, S the energy of the primary re-emitted as scattered radiation, and E_K, E_L, etc., were the energies absorbed in association with the emission of the respective characteristic rays, then $E = S + E_M + E_L + E_K + E_J$. The total corpuscular radiations of energy C could similarly be divided into groups: $C = C_M + C_L + C_K + C_J$. While the general absorption experiments had chiefly been made on metals, the K radiation had particularly been measured in the case of bromine, and it resulted that it required more primary energy to expel a K electron than an L electron, and that a quantum of K radiation was probably the energy required to move an electron from the K position to the L position, and that further one quantum of K characteristic radiation was emitted for each K electron ejected.

The atom of Prof. Barkla would thus consist of a central nucleus of positive electricity surrounded by concentric rings of electrons of the J, K, L, M types; the K electrons, being nearer the center, would require more energy for expulsion than the L electrons; but they would all be ejected from the atom at the same velocity. A displaced K electron would leave a gap, into which an L electron (possibly also an M) might drop, the energy previously absorbed in displacing the K electron being re-emitted as a quantum of K radiation. When the primary wave-length μ_1 was just less than its characteristic wave-length μ_2, the energy was almost equally divided between the characteristic E and the corpuscular radiation C. As μ_1 decreased, the C energy increased, and for very short μ_1 nearly all the energy would be taken up by the corpuscular radiation. In the case of bromine the division was not quite equal, the fluorescent radiation making up only 0.47 (instead of 0.5) of the total; for elements of higher atomic weight the value 0.5 was nearly attained.

Finally, Prof. Barkla stated that as the generation of a radiation of a given frequency by cathode rays necessitated the incidence of electrons with energy greater than that of a quantum of that radiation (even for the production of radiation not recognizable as characteristic of the respective anti-cathode), it seemed probable that the process of X-ray generation was itself one of the same character as that resulting in the emission of characteristic X-rays, and that mere collision should produce X-rays was doubtful. Though X-radiation might be and was emitted by electrons (probably by groups of electrons or even atoms) as a continuous process and in any quantity whatever, also in fractions of a Planck quantum, it was emitted in quanta from atoms when certain critical conditions were reached. In this sense Prof. Barkla spoke of a quantum theory of atomic energy rather than of a quantum theory of radiation. The full consequences of his theory had probably not been worked out yet; some of his conclusions had been confirmed by W. Kossel; some might require modification.

In commenting upon this very important contribution to fundamental research, Sir J. J. Thomson, president of the Royal Society, remarked that he agreed that the emission of an electron carried by a unit of X-ray radiation was, so to say, the death of that unit. But he did not go so far as Prof. Barkla in putting the corpuscular radiation—in the old sense—altogether out of court. Referring to his recent Royal Institution lecture on radiation, he drew attention to the way in which, he thought, the orthodox theory of light and the quantum theory could be brought into harmony.—*Engineering.*

[1] Delivered at the Royal Society.

Mica in Russia

BEFORE the war, all the mica used in Russia was imported from Canada or India, and this fact appears strange when looked at from a historical standpoint, for in former times Russia was a center of mica production. But this period lies very far back, and dates from the time when mica was used for windows before window-glass came into its present use. It is stated that in 1681 Russia exported 42 tons to Holland, 40 to England, and 8.6 to North America. Why such an extensive industry should have fallen off may be accounted for by the advent of window-glass and from the fact that the later industries using mica had not yet arisen. But an effort is now being made to exploit the sources of mica, which are said to be abundant in various parts of the country, especially as this product is scarce during the war. At last accounts, the annual consumption was 820 tons, but since the war the conditions are greatly changed, and the price is said to have gone up to ten times the former value.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, JULY 29, 1916

Published weekly by Munn & Company, Incorporated
Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer;
all at 233 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876) per year $5.00
Scientific American (established 1845) . . . . " 3.00
The combined subscription rates and rates to foreign countries, including Canada, will be furnished upon application
Remit by postal or express money order, bank draft or check

Munn & Co., Inc., 233 Broadway, New York

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

Table of Contents

PAGE
Automobiles and the Great War—I.—By W. F. Bradley.. 66
Shadow Pictures by Parallel Rays.—8 illustrations...... 68
Feeding the Firing Line.—by W. S. Hiatt.............. 68
Shooting Soot from Chimneys.......................... 69
Water Pressure....................................... 69
The United States Government Libraries at Washington.—By H. H. B. Meyer.......... 76
Cutting Efficiency and Hardness of Tool Steels.—By J. O. Arnold 71
Making High Vacua.................................... 71
British Methods of Handling Coal.—By James Steelman.—6 illustrations.......... 72
Contagion from Clothing.............................. 73
A Generating Station Danger.......................... 73
Modern Views of the Sun—II.—By J. S. Plaskett....... 74
The Process of Case Hardening.—By R. A. Millholland... 75
An Electrically Conducting Paint..................... 75
Bird Houses.—By Ned Dearborn.—7 illustrations....... 76
The Preparation of Surgical Catgut................... 76
The Economic Possibilities of the Danube as a Cosmopolitan Highway.......... 77
The Determination of the Resistance of Ships.—By Ernst H. Rigg 79
Plasticity and Viscosity............................. 79
X-Rays and the Theory of Radiation...................80
Mica in Russia....................................... 80