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The Editor is always glad to receive for examination illustrated articles on subjects of timely interest. If the photographs are *sharp*, the articles *short*, and the facts *authentic*, the contributions will receive special attention. Accepted articles will be paid for at regular space rates.

GROWTH OF AMERICAN UNIVERSITIES.

The safeguard against and corrective of the evils of our vast immigration are to be found in our excellent public school system; and so, on the other hand, we may say that the greatest safeguard against the perils which attend on the increase of the opportunities for accumulating rapid wealth, and the temptations and opportunities to acquire that wealth by devious ways, is to be found in the rapid growth of our universities, and the splendid moral and mental equipment which they offer to the youth of the country. We know of nothing that augurs so well for the future as the fact that the development of our universities is moving forward at an ever-accelerating rate. Indeed, during the past decade they have grown even faster than the population. The record of growth of thirty of our leading universities shows that from 1895 to 1905 the increase in the number of students has been as follows: Harvard attendance has risen from 3,550 to 4,559; Columbia, from 1,942 to 4,056; Michigan, from 2,818 to 3,742; Minnesota, from 2,233 to 3,633; Illinois has made the extraordinary jump from 607 to 3,391; Wisconsin has increased from 1,671 to 3,390; Cornell, from 1,689 to 3,330; California, from 1,787 to 3,200; Yale, from 2,350 to 3,124; Chicago, from 1,524 to 2,901; Northwestern, from 2,413 to 2,481; New York, from 975 to 2,882; Stanford, from 1,100 to 1,552; and Princeton from 1,109 to 1,384. This represents an increase of from 0.28 per cent in the case of the Northwestern University to as high as 459 per cent in the University of Illinois. Now, in the ten years from 1890 to 1900 the increase of the population of the United States was about 22 per cent; while during the same period at thirty universities the attendance increased 65 per cent. Among the many encouraging features in the growth of this country, there is none that carries brighter promise for the future than this ever-widening appreciation of the great educational institutions of the country.

GASOLINE ENGINES AND THE TORPEDO BOAT.

It was only a question of time before the internal-combustion engine would be given a serious trial in the propulsion of torpedo boats. The valuable quality of developing large power in proportion to the weight of the engine, and the wide radius of action for a given weight of fuel which can be secured by the use of gasoline, are qualities which have always commended themselves strongly to the consideration of the naval architect. The first serious attempt to produce a motor-driven torpedo boat of practical size and seagoing ability has recently been made by Yarrow, and he has succeeded in turning out a craft whose success was so pronounced that it has been purchased by the Admiralty, and seems likely to become the nucleus of a fleet of similar boats.

Of late years there has been a tendency to depart from the essential principles upon which torpedo flotillas were built. The original theory was that these flotillas should be made up of a large number of small craft, each of high speed, and presenting, because of its small size, a difficult object to hit, and costing but little to build. In the desire to raise the speed, the designers have been driven to increase the length, until from their original 75 feet torpedo boats have grown to an over-all length of 150 feet. The increase in their cost has necessarily led to a decrease in the number to be built, and consequently torpedo flotillas have lost that most valuable element of bewildering numbers, on which the chance of getting home a successful blow on a warship so largely depended.

In casting about for a type of boat which would accommodate itself to the demand for a restriction of size, it was realized that the motor-driven boat presented the best possibilities, and the matter has been so well worked out that the new motor torpedo boat, although it is only 60 feet long by 9 feet beam, has proved able to make a trial speed of 26.15 knots and sustain 24 continuously on a sea trip of many hours' duration. The economy of weights which has been secured by the adoption of the gasoline motor is shown by a comparison of this vessel with a torpedo boat of similar dimensions driven by steam, which, if it were carrying the same load, would be able to attain only 18 knots an hour as compared with 24. Furthermore, the radius of action of a steam-driven boat for one ton of coal would be only 60 miles, whereas for one ton of oil the motor-torpedo boat would be able to cover 300 miles. The fact that the little craft weighs only 8 tons, and is but 60 feet in length, adds enormously to its mobility in naval operations; for a whole flotilla of them could be loaded on to the cars, and transported to any desired point along the coast with ease and dispatch. The probable method of defense with these vessels would be to arrange a series of special stations, at the mouths of the rivers or harbors, where they could run in for shelter or supplies, and so protect a long stretch of coast line with a continuous chain of torpedo defense, which could be quickly concentrated by rail in large numbers at any point which might be threatened. Although for aggressive operations such craft as these can never in any sense supersede the battleship, it is worthy of note that over three hundred of them could be built for the price of a single "South Carolina" or "Michigan."

NORTH TUBE OF HUDSON RIVER TUNNEL COMPLETED.

It is seldom indeed that an enterprise so vastly important as the construction of the two great railroad tubes by means of which the Pennsylvania Railroad Company is to gain a long sought admission into the city of New York beneath the Hudson River, is forced to its completion with such rapidity and with such little ostentation. Public attention has been centered upon the huge excavation for the terminal on Manhattan Island, and upon the serious difficulties which have attended the driving of the tubes beneath the East River; and since the sinking of the shafts for the Hudson River tubes, practically nothing has been heard of the truly remarkable speed with which the two tubes were being pushed through to a connection beneath the river. Work on the tunnel proper commenced on the New York side on April 18, 1904, and on the Jersey side on September 1 of the same year. The shields of the north tube met on September 12, and at the present average rate of driving the shields of the south tube will meet about the 7th of next month.

The improvements now under way for giving admission to the Pennsylvania Railroad to New York and Long Island will cost altogether about $100,000,000. The North River division of this work, extending from the new terminal at Thirty-third Street and Eighth Avenue to the Hackensack Meadows, west of the Palisades, has a total length of 13,700 feet, and the length of the tunnel proper, lying directly beneath the Hudson River, is 6,100 feet. The tunnels on both sides of the river were driven through rock without the use of shields, to as great a distance as the nature of the material would allow, and in this portion of the work serious and rather puzzling obstructions in the way of piles, cribwork, and riprap, were encountered. As soon as the river mud and silt were entered, the shields were set up and the driving progressed steadily and rapidly and with a remarkable absence, for this kind of work, of fatalities and serious accidents. One miner lost his life by being suddenly submerged in quicksand, and there was one death attributed to the effects of compressed air. It must not be supposed, however, that the success in driving the tunnel was due to the absence of difficulties of a physical nature; for the greatest care had to be exercised in maintaining the pressure at the proper point to prevent a sudden blowout and the inflow of quicksand into the tube. This was particularly the case on the Jersey side, where, at a depth of 85 feet, a freely-flowing quicksand was encountered. On the New York side, moreover, not far beyond the bulkhead wall, the tunnel passed through silt, the surface of which lay dangerously near the bottom of the river. The difficulty at this point was overcome by the well-known expedient of dumping clay and forming a blanket on the river bed, which effectively prevented air-blowing. As the shield progressed, the heavy segmental rings were put in place, and the work advanced so rapidly that on one occasion as much as 12½ feet of distance was made in eight hours. The work remaining to be done consists in driving through the bottom of the tube a row of massive cast-iron screw piles, which will be sunk until they reach the underlying rock. These will be fastened securely to the tube, and will form a series of piers, upon which the structure for carrying the roadbed will be laid. The interior of the tube will be entirely lined with about two feet of concrete, which, in conjunction with the massive cast-iron shell and the heavy screw piles, will render the work so stable as to insure the permanency of these tunnels for all time.

STEEL PASSENGER CARS FOR TRUNK RAILROADS.

It is good news to those of us who realize that the loss of life on steam railroads is altogether too large, to learn that at last one of our great trunk lines has decided to adopt the all-steel passenger car as a standard type for all new equipment. The steel car, as we have often pointed out in the columns of this journal, is the only sure preventive of those two fruitful causes of death and injury in railroad wrecks, namely, telescoping and fire. Telescoping, or the crushing of one car directly into the one adjacent to it, should, more strictly speaking, be known as shearing; for when telescoping takes place, the mischief is due to the massive and enormously strong platform of one car lifting above the one adjacent, and sliding forward upon it, cutting through the light framework of the sides until the body of the telescoped car is cut loose from the under-framing. As the entering platform is forced resistlessly along the surface of the one on which it climbs, its forward edge passes through the car, usually at about the level of the passenger seats, and the passengers are crowded forward, mixed up with the wreckage of the seats, the splinters of the framing, and the fragments of heavy plate-glass windows, with all those resulting horrors with which we are only too familiar. The risk of fire is due to the ignition of the combustible woodwork of the car and its yet more combustible paint and varnish, by the inflammable illuminating gas, or the scattered white-hot coals from the engine firebox.

Obviously, the best preventive of telescoping is to so construct the cars that the end framing of the body and the vestibules will be strong enough to prevent the shearing action of the platforms; and it has at last come to be realized that the only material which presents the proper resisting qualities is the wonderfully tough and elastic mild steel of which we build our skeleton buildings, our bridges, and our steamships.

Great credit is due to the Pennsylvania Railroad Company for its determination to build its future passenger cars of steel. We understand that the first order for the passenger-car equipment to be used in the Hudson River tunnels and the new Manhattan and Long Island stations is to be of steel throughout, and that one thousand of the new cars are to be ready as soon as the tunnels and station are completed. The Pullman Company is now constructing the first all-steel sleeper car, which if it gives satisfaction, will be followed by five hundred Pullmans of similar design. The main feature of the new car platform is a massive central box girder, 24 inches wide by 19 inches deep, which will extend throughout the full length of the car from coupling to coupling. From this backbone, deep steel cantilevers will extend transversely, four on each side, to carry the sides of the car, which will be composed of steel girders of unusual strength. The floor framing will be covered with a continuous flooring of steel plates, strongly riveted to the steel longitudinal girder and the cantilevers of the floor framing; and over this plating will be placed a cement finish in imitation of stone which will be laid while in the plastic condition. Security against telescoping will be obtained by making the steel vestibule end and corner posts of such a form and strength as will present great resistance to transverse shearing; and should the adjoining platform be forced through these, it will bring up against the end door posts, which will be of a very deep section, securely riveted to the main box girder of the platform, and to a horizontal steel strengthening plate at the roof of the car. Inside and out, the lining will consist principally of steel plating, and no wood or inflammable material whatever will be used except for the top of the seat arms, where it has been introduced for the comfort of the passengers. The car is equipped for electric lighting, the current for which is furnished by storage batteries placed beneath the car; and it is to these batteries largely that the great weight of the new car is due; for while the standard wooden coach weighs about 85,000 pounds, the new steel car has a weight of 103,550 pounds. This increased weight, while it will be looked at dubiously by the master mechanic who has to provide the motive power, has the advantage that it greatly reduces vibration and noise and, therefore, adds to the comfort of the passenger.

JAMES DREDGE.

The field of technical journalism has suffered a heavy loss in the recent death of the late James Dredge, editor of our esteemed contemporary Engineering. Among engineers there were few contemporary names more widely known than his; for outside of his editorial work, which extended over a period of thirty-three years, Mr. Dredge was honorably known for the active part which he took in the great international exhibitions. He was identified with the Vienna exhibition of 1873, and later with the Centennial exhibition at Philadelphia of 1876, and the Paris exhibitions of 1878 and 1899. He was a member of the British Commission for the Chicago exhibition of 1893. He held similar official positions with the Antwerp exhibition and that held in Brussels, and he was one of the vice-presidents of the British Commission for the Milan exhibition of the present year.

Mr. Dredge was born at Bath, July 29, 1840. He was educated as a civil engineer, and it was in the course of his professional work that he first made the acquaintance of the late Zerah Colburn, and that other distinguished engineer, the late Alexander L. Holley. Zerah Colburn, who had held the position of editor of The Engineer, London, left that journal to establish one of his own, the first number of which, under the title of Engineering, was published in 1866. It was through Mr. Colburn that Mr. Dredge became one of the staff of the journal with which he was to be honorably associated for so many years. Not only was Mr. Dredge a frequent visitor to this country; but at all times he took the most lively interest in its growth and prosperity. Conspicuous among his early writings were a series of articles on American works, included in which was a series of articles on one of the leading American railroads, which was subsequently published in book form. The visit of Mr. Dredge to this country in 1890 was made for the purpose of delivering an address in connection with his unveiling of a bronze bust of Holley in Washington Square, New York. He was a member of the British Institution of Mechanical Engineers and of the Institution of Civil Engineers. He was also elected an honorary member of the American Society of Mechanical Engineers.

THE ADVANTAGES OF CRANK AXLES FOR LOCOMOTIVES.

BY W. F. CLEVELAND.

The pistons of a locomotive, and their reciprocating connections, during acceleration and retardation stresses, may be considered, so far as these disturbing forces are concerned, as captive projectiles, whether propelled by steam in the cylinders, or through the cranks and axles, by the momentum of the train when steam is shut off. In the former case, their unbalanced inertia is applied to the cylinder heads in precisely the same way as the recoil of a gun is occasioned, and induce the racking strains which occasion the serious repair bills, itemized as broken frames, deranged adjustments, bad steam distribution, and a hundred other ills, that may be diagnosed as general locomotive debility.

During the excessive speeds of modern railway travel, the strains induced by the unbalanced inertia forces of these parts are largely occasioned when steam is shut off in the descent of grades and the approach of stations. The strains are then applied through the rods and cranks to the frames at the main bearing connections, the momentum of the train being the propelling energy, but the destructive effects are of the same character and proportion. They are partially and inadequately balanced by the counterweights, whose service is further vitiated by the variable track pressures which they induce, and by the unbalanced strains of their continued action at both centers, when the inertia of the piston and its connections has been removed. During piston acceleration, the effective steam pressure, as measured by the crank stresses, is diminished to the extent of the static inertia of the reciprocating parts, which is also unbalanced to an equal extent, but the loss is repaid by the dynamic inertia of retardation in the latter half of the stroke.

The retardation stresses of the latter half of the piston stroke are applied to the cranks, in unison with those of the effective steam pressure, but as the latter are balanced between the piston and the cylinder heads, the former remain unbalanced, except by the untimely action of the counterweights, and like a retarded or captive projectile, communicate their disturbing forces, through the rods and cranks, to the main bearing connections, where they are absorbed by the frames and general mass of the locomotive. These forces of retardation and acceleration of the reciprocating parts act in unison with the course of the train's motion during one-quarter of each revolution of the drive wheels, but in contrary directions to one another during the next quarter. That is, with the piston of the left-hand engine at the upper (crank position) half stroke, and the opposite piston at head center, the retardation stresses, during the ensuing quarter, on the one side, and the acceleration stresses on the other, both act in unison with the direction of the train's motion; but in the next quarter they act in contrary directions to one another, as the change from retardation to acceleration takes place with the reversal of the piston motion, and the change from acceleration to retardation during the course of the piston stroke. The conditions and changes are the same at the back centers, except that the directions of the disturbing forces are reversed. The cycle thus begins with these forces acting in unison for one-quarter of a revolution, and in the direction of the train's motion, then changing, during the next quarter, to contrary directions to one another, then acting in unison during the third quarter, but contrary to the direction of the train's motion, and during the last quarter, pushing or pulling in contrary directions. The conditions will be more readily understood by keeping in mind the fact that, during the piston acceleration and retardation of the first quarter of the cycle, the pistons move in contrary directions, and therefore the disturbing forces act in unison of direction, because the acceleration forces are always contrary, and the retardation forces always in harmony, with the direction of the piston movement. During the second quarter of the cycle, the pistons move backward in unison, and the disturbing forces are therefore contrary to one another in direction, and so on to the end of the cycle.

It is therefore evident that the conditions are far worse than if these forces continually acted in contrary directions, as the sudden changes at each quarter revolution, even at moderate speeds, are productive of racking strains, aggravated by lost motion in the working parts, and culminating in crystallization and breakage of the frames, and impairment of the general efficiency of the locomotive.

A most satisfactory change for the better may be effected, however, simply by the use of crank axles, placing the cranks as closely together as possible, in order to centralize the strain, and at the same time protect the cylinders from heat radiation and cylinder condensation, by their inclosed positions. During the first and third quarters of the cycle, when the disturbing forces act in unison, the distribution of the strain will be practically the same as with outside cylinders, and no racking stresses will be occasioned; but during the other quarters, when the disturbing forces are contrary in direction, the approximately central positions of the cranks, considered in connection with the inertia of the wheels and outer parts of the axles, will eliminate the racking strains, and practically balance the disturbing forces. Light counterweights only will then be required to balance the coupling side rods and wrist pins.

Crank axles have been in use for many years on English railways. It is claimed that American locomotives have made a poor record on these roads in endurance competition with those of English manufacture, and the main cause is probably not far to seek; but the prejudice against crank axles in America is gradually being eliminated by improved methods of manufacture, and by the unqualified success of balanced compound locomotives running in this country.

INVESTIGATING THE NUTRITIVE VALUE OF MEAT.

BY ELIZABETH C. SPRAGUE.

A billion and a half dollars are spent every year by the people of the United States for the meat they eat—about a third of the whole amount expended for raw food materials. This immense sum is used to purchase a food of whose nature and dietetic value very little is known. Every one thinks he knows from experience what suits him best, or at any rate, as one woman expressed it, "likes to eat what he likes, and not what is nourishing."

It has proved financially profitable to study the food of plants, to analyze the soil where they are to be grown, discover what food element is lacking, and by supplying this produce a more perfect and plentiful crop. Extensive experiments are carried out to determine by what system of feeding the most marketable steer yielding the largest profit can be raised. Even the question of whether the corn should be ground into a meal or fed to the animal on the cob is thought worthy of consideration and experiment. This, because the value of such care and experiment can be demonstrated in the returns in dollars and cents. A man's health, strength, and efficiency depend upon the food he eats, but it is less easy to show the results of experiments with human beings than with plants and the lower animals. In matters of food more than in anything else the human race has been content to follow its instincts. Now, however, the time has come when it does not seem sufficient to depend upon these alone. We have begun to appreciate the ability of science to first interpret the leadings of instinct, and then discover means of improving upon them. Through the domestic science movement many of the more intelligent housekeepers have come to realize the need for more accurate information regarding the nutritive and economic value of different foods, of methods of cooking, and related subjects. To supply this need the government, through the Office of Experiment Stations of the Department of Agriculture, has established a system of Nutrition Investigations. These include studies of the food consumed by typical individuals, families, and groups in colleges, hospitals, and other institutions, to determine representative food habits, to discover the principles underlying the natural selection of food, and to establish a rational basis for such selection.

While very few people in civilized countries actually starve, many have less food than they need, and multitudes have less than they would buy if they could. On the other hand, many people have more food than they should have. Careful preparation and skillful cooking fits much food for use which would otherwise be thrown away, and makes what is already edible more easily available, and therefore more valuable to the body. We do not, however, know a great deal about the effect of cooking upon food and its influence upon digestibility. Moreover, whenever money is scarce and the most should be made of food, there the ignorance, carelessness, and incompetence of the cook are proverbial. Therefore the nutrition investigations have included researches upon the preparation of some of the most important articles of diet, particularly bread and meat. It seems especially suitable that the investigations upon the chemistry of meat should be carried on in Illinois, which contains the greatest distributing center for this food in the world.

At the University of Illinois several laboratories of the Department of Chemistry are devoted to this study. Not only are different cuts and kinds of raw meat analyzed to discover differences in composition and therefore in nutritive value, but they are also cooked in various ways to determine the comparative value of different methods of cooking, the losses and changes in composition which occur, and the influence of these upon the digestibility of meat.

A standing rib beef roast, for instance, is shown by analysis to consist of 42 per cent refuse or inedible material, bone and gristle, 24 per cent water, 26 per cent fat, 7 per cent proteid (muscle-building substance), 0.7 per cent organic extractives. Therefore, if one pays 75 cents for a 5-pound roast of this character, 31 cents goes to pay for waste material and 43.5 cents for edible meat divided as follows: 18 cents for water and 25.5 cents for the actually nutritive material.

The same roast, boned and rolled ready for cooking, would weigh about 3 pounds, 44 per cent of which would be water, 12 per cent proteid, 1.4 per cent organic extractives, 41 per cent fat, and 0.6 per cent ash. After cooking it would weigh about 2½ pounds if cooked very rare, and contain 40 per cent water, 14 per cent proteid, 43 per cent fat, 1.5 per cent extractives, and 0.7 per cent ash. Having lost more of water than of the other constituents during cooking, it has become more concentrated, and a pound of the cooked meat contains as much nutritive material as 18 ounces of the raw meat.

It is difficult for the uninitiated to appreciate the extent of the work involved in such investigations, but some idea may be gained from the fact that a single cooking experiment, including the analysis of the meat before and after cooking and of the accompanying broth or drippings, means that one hundred and forty chemical determinations must be made—sufficient work to take all of one man's time for three weeks. Moreover, each cooking experiment must be repeated a number of times, in order to collect sufficient and indisputable evidence to justify definite conclusions. In the course of these investigations nearly a hundred raw meats have been analyzed, and three hundred cooking experiments performed. Results which are of practical as well as scientific value have been obtained.

When meat is cooked in water, it may lose from 10 to 50 per cent in weight, depending upon the conditions of cooking. Most of this loss is due to the water cooked out of the meat. Almost half of the water present in the raw meat is lost in this way, so that it is not surprising that boiled meats should seem so dry. Meats cooked by roasting lose from 13 to 37 per cent of their total weight. Only about a third of the water is lost under these conditions, leaving the meat much more juicy. The roasted meat loses very much more fat than does the boiled meat, but this is not important, since it may be saved in the drippings, and more fat probably remains in the meat than will be eaten.

The loss of the organic extractives—a class of substances about which very little is known, except that they are responsible for the flavor and stimulating effect of meat—is quite a different matter. When the meat is broiled or roasted only a small part of these exude, but if they are cooked in water more than three-fourths of them are dissolved and pass into the broth. The meats from which the soluble constituents have been removed are very much less effective in stimulating the flow of the digestion juices, and therefore have a lower dietetic value than those which retain more of these substances. The juiciness, tenderness, and flavor of a roast or porterhouse steak are of sufficient physiological importance to justify to some extent a preference for these, even at the higher price one must pay for them, than for meat for boiling or stewing.

In cooking meats in water the losses increase with the length of time and temperature of cooking. The smaller the size of the pieces in which the meat is cooked, the greater also will be the losses. In roasting the losses increase the more thoroughly the meat is cooked. Meat that is cooked well done loses fully twice as much as that which is left rare. This means that the latter is not only more juicy, but contains more of the soluble flavoring constituents than the former. Being in a condition that resembles raw meat, it is more easily though not more completely digested than is the well-done meat. All meats, irrespective of the method of cooking, have a high food value when judged by the kind and amount of nutritive ingredients present.