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.