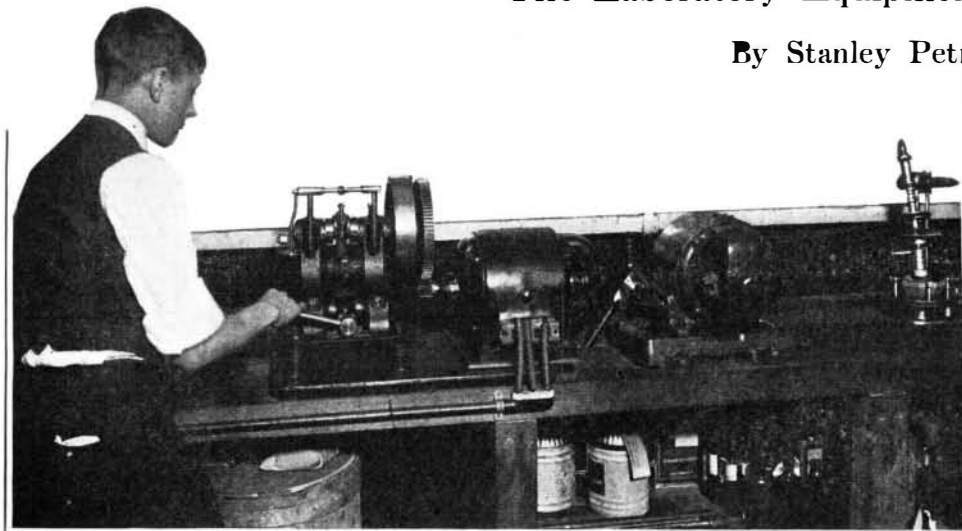


How Automobile Materials Are Tested

The Laboratory Equipment of Great Factories

By Stanley Petman, M. E.



An impact machine for determining the fatigue point of metals.



A camera which makes micro-photographs.

ALTHOUGH there is little doubt that racing has had a beneficial influence on the automobile industry in that it has made plain certain weaknesses in the construction of cars and pointed out the way to their elimination, there is nothing that has had, and still has, a more direct influence on the perfecting of parts than the immense amount of laboratory work that is done. There are few who own or drive cars who realize the scope of such work or who know that nearly every automobile factory of any size maintains a well-equipped chemical and physical laboratory where every day hundreds of dollars worth of valuable parts are deliberately smashed, or dissolved or burned up just to find out exactly what they are composed of and how much strain they will stand.

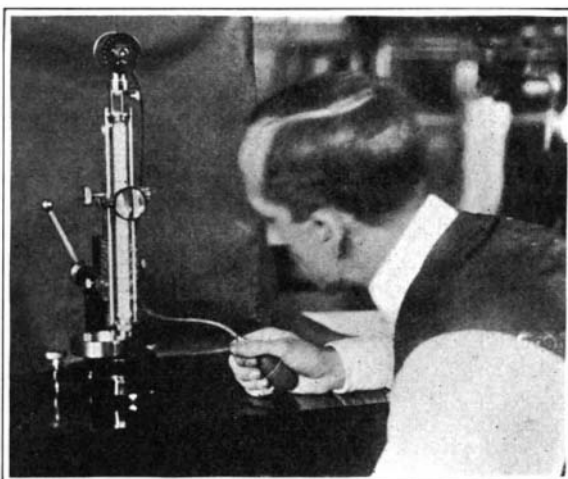
This laboratory side of the automobile industry is an interesting side for its shows to what lengths an automobile manufacturer will go to determine within the finest possible limits the structure and characteristics of the materials he uses. Nor is such work confined to automobile factories alone; part makers as well, of which there is a legion, maintain their own laboratories in a great many cases. Though the source of their metal supplies may be relied upon, they prefer to take no chances, and ever and anon the testing and trying goes on—to the ultimate benefit of the automobile user, of course.

Testing Steel for the Automobile.

Just as surely as steels enter largely into the construction of the automobile just so surely has their perfection been responsible for raising the modern car to its present plane of perfection. There are hundreds of different kinds of steel each suited only for a particular kind of work and each varying possibly by only a fraction more or less of a certain element in its composition. Thus, for instance, the greater the carbon content in steel, within certain limits, the harder can it be tempered.

Suppose for example that a steel is to be developed, which, theoretically, should temper to a certain hardness and at the same time show other properties such as elasticity and toughness. Experience indicates that

No automobile manufacturer of repute sells a car every part of which has not been scientifically tested. Wonderful testing laboratories now constitute an essential part of every well-equipped automobile factory. The result is that year after year the automobile ascends by another rung in the ladder of efficiency. The object of all this laboratory work, stated in the fewest possible number of words, is to discover why something that works out beautifully in theory so often fails in practice. In this article the more important methods of laboratory testing are disclosed and the machinery used illustrated.—EDITOR.



A machine for testing the hardness of metals.

certain elements should be added to the raw material in order to obtain these properties, and the steel is made accordingly. Then it is tested for hardness with an instrument styled a scleroscope; an instrument that consists, briefly, of a graduated glass tube, like a thermometer, containing a small pointed piece of steel of known weight. The specimen to be tested is clamped in place beneath the weight which is permitted to drop on it. The height to which it rebounds, ascertained by means of the graduations, serves as an indication of its comparative hardness. If the specimen comes up to expectations, it is put to other tests to determine its other properties. But if it does not, it is analyzed to find out just what is the matter with it and how it may be improved so that it will render better service.

As the amount of carbon content bears direct influence on the degree of hardness that can be obtained, one of the first steps is to determine accurately the percentage of carbon it contains. Probably the quickest and surest way of obtaining the information is to burn the steel and measure the carbon that is set free. This is done by placing a known weight of steel filings in an electric furnace, raising the temperature to about 950 deg. Cent. and passing purified oxygen through it. The oxygen combines with the carbon to form CO_2 , which passes out and is absorbed in weighed bulbs of caustic potash. By simple computation, in which the increase in weight of the caustic potash bulbs is multiplied by the constant .273 and divided by the weight of metal placed in the furnace, the percentage of carbon is ascertained directly.

Even where steel alloys have been developed and selected for certain uses and are giving continuously

good service, the testing is still carried on to make certain that subsequent alloys are equal to the original. Samples from every batch are analyzed and tried, and in this way the manufacturer of the car knows that the material in John Smith's car is as nearly like the tried and tested material in his own experimental vehicle as human ingenuity can make it. It is insurance for the car owner.

In the development of nearly all steel alloys used in automobile construction, heat treatment, which a few years ago was virtually unknown, plays a very important part. The steel for each particular purpose—for axles, for gears and for springs—must be tempered just so and just as a batch of bread may be ruined in the baking, either over-done or not done enough, so may a batch of steel be ruined in the tempering process.

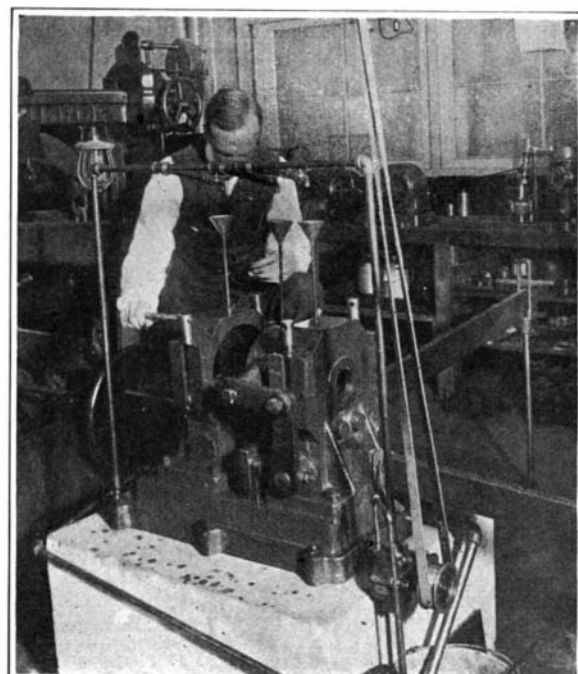
How Defects in Broken Axles Are Studied.

Suppose, for instance, that a number of broken axles have been reported to the factory. A part of one of the axles is sent to the laboratory, polished and placed under the eye-piece of an instrument styled a micro-metallagraph. A powerful arc light is focused on it. If the steel, for example, is 0.9 carbon and has been properly heat treated its surface will appear pebbled all over and the color will be uniformly gray. If, on the other hand, it has not been properly heat treated, the surface probably will appear mottled showing the presence of cementite. If it has not been hardened at all, which is unlikely, but is in the normal condition, the surface will show a dark etching constituent which microscopically is termed pearlite. In any case, the chemist can tell at a glance whether or not a specimen has been properly heat treated.

Physical testing, of course, is no less important than chemical analysis, for by its aid the connecting link between theory and practice is made apparent. The steel, which is used in ball bearing races, for instance, must be capable of being tempered very hard; it must be tough and fairly elastic; and above all it must be wear resisting to the greatest possible degree. All of which is known and a suitable steel for the purpose can be laid down in theory. After the steel is made,



An apparatus for electrically analyzing copper alloys.



Ball-bearing load-testing machine.

the ball bearings are placed in special apparatus and run under service loads for what is the equivalent of years and years in a car. If they "stand up," well and good; but if they do not, they are analyzed and tested, and it is discovered wherein they are wrong, thus reconciling theory and practice.

Powerful Testing Machines for Abusing Steel.

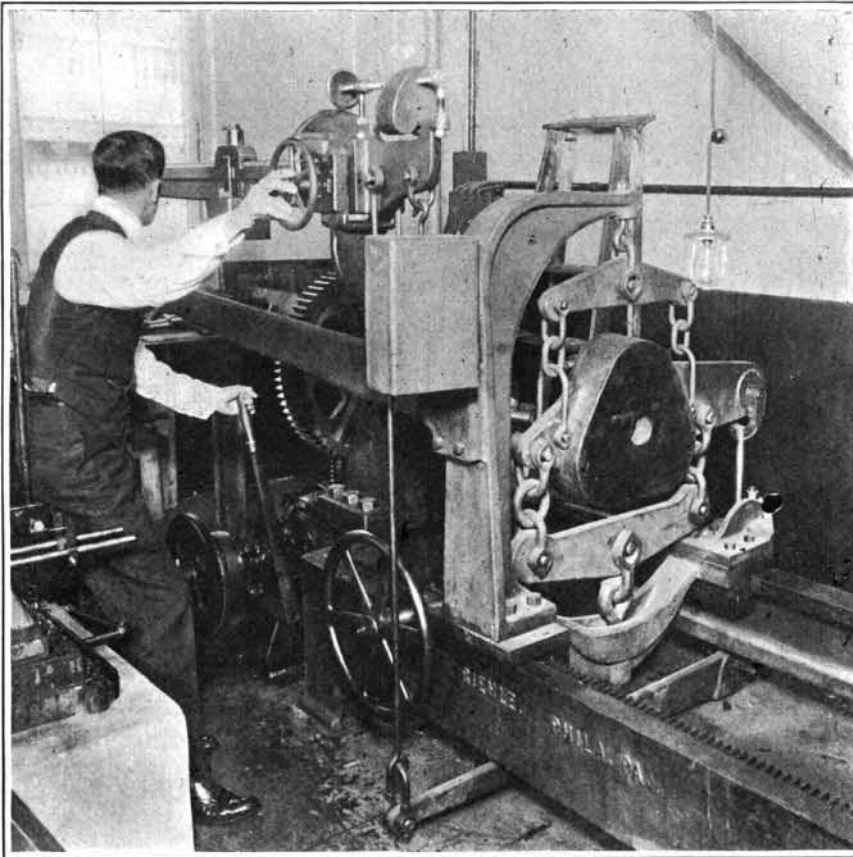
For the testing of steels in which great tensile strength or a comparatively high degree of elasticity or toughness is desired, a number of pieces of special apparatus has been developed. In them, the steel is bent and twisted and squeezed and stretched and otherwise abused until its characteristics have been ascertained and recorded for future reference. Among these pieces of apparatus, the torsion testing machine is a marvel of strength and accuracy though its operation is quite simple. If a crankshaft is placed between its untiring jaws and the power applied, slowly but surely it will be twisted almost out of all semblance to its original shape, just as if it were so much cheese or putty. The dials reveal the fact that no less than 85,000 pounds pressure has been required to deform it permanently. Needless to add, no crankshaft in an automobile engine ever is subjected to a twisting strain of 85,000 pounds in normal service. The purpose of the machine is to determine just how much twisting a crankshaft, or any other part, will stand before it takes what is known in engineer's parlance as a "permanent set"; in other words, it is to determine the elastic limit of the metal.

The tensile testing machine accomplishes a somewhat similar purpose. It is another piece of apparatus that is designed for a sort of destructive criticism that in the end is constructive; it pulls things apart, and in doing so gives valuable information. Its massive jaws grip the two ends of a prepared specimen of metal, and at the touch of a lever the metal is stretched out to the breaking point, which is exactly what the operator wants to discover. When the arm of the machine balances, he knows that just a very little more stretching will rupture the specimen and that a specimen showing a tensile strength of 119,000 pounds to the square inch, an elongation of 18.5 per cent and a reduction of area of 59 per cent is a suitable steel for front axles, for example. If a specimen of steel on test will not show these characteristics it is not suitable for that particular work, and it is discarded in favor of something else. Always, new materials are tested in this way before they are put to work.

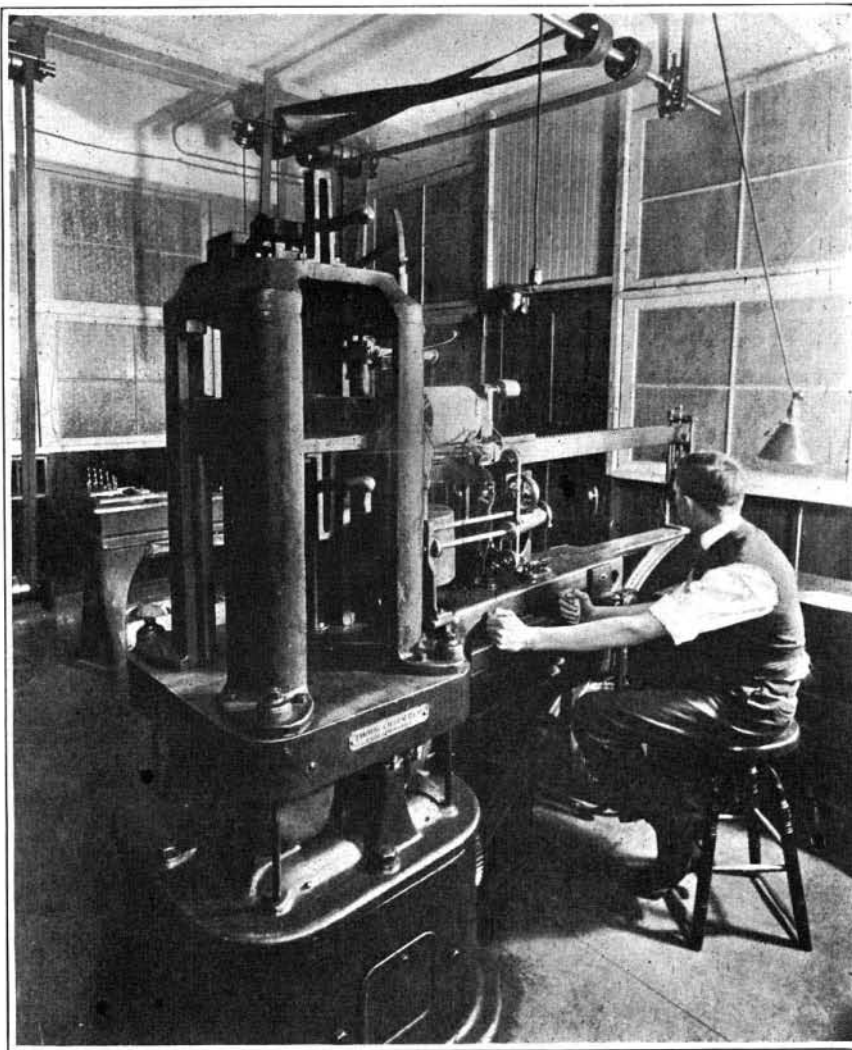
As an interesting case in point, to show the object of physical testing and the benefits which accrue from it to the owner of a car, the steering knuckles and the impact machine are particularly apropos. Other than the braking mechanism of a car, there is nothing that is of greater importance than the steering apparatus. To be absolutely dependable it requires to be made of materials which have characteristics peculiar to themselves. The steering knuckles must be capable of sustaining tremendous strains, and at the same time they must not give way under continuous vibration, which operates to crystallize the metal and cause fractures.

With the impact machine the laboratorian can determine exactly how much vibration a given specimen can be expected to withstand in service. A standard size sample is placed in the machine and repeatedly struck blows of a known strength until the metal literally is tired out and fails. The number of blows required to break the specimen serves as an infallible indication of its resistance to fatigue. For the examination of copper alloys, of which there are upward of 25, the electrical method is perhaps the simplest and the most accurate. Bearing bronze, for instance, is dissolved and placed in a platinum dish, the whole is placed in a piece of special electrical apparatus, and immediately the current is turned on, the copper commences to deposit on the dish. After the action ceases the dish is weighed, the increase in weight representing pure copper. The percentage of copper in the alloy determines its suitability for a special purpose.

All such testing and trying is of special interest to the automobile owner. The policy which a few years ago dictated that a certain number of cars be built and put on the road in the hands of owners that their faults might develop for correction in the next batch of cars, now is obsolete. It was not very long before automobile manufacturers came to realize that such a policy was not only false economy, but ruined their reputations as well. And the net result of the realization is reflected in the splendidly equipped and carefully main-



The torsion testing machine.



The tensile testing machine.

tained testing laboratories connected with most automobile factories, where present excellence of products is calculated to serve as a basis for future reputation.

Explorations in French Guiana.—Under the auspices of the Society of Geography, of Paris, a well-equipped expedition, led by M. Jean Pilinski de Belty, is exploring the unknown mountainous region near the southern border of French Guiana, about the headwaters of the Araoura and Camopi rivers.

Water Clouds at Low Temperatures

CONSIDER a fog in winter, with a temperature far below freezing. Ice fogs are not unknown, but the ordinary winter fog, however low the temperature, consists of water drops. The water is supercooled. When brought into contact with a solid object, water in this metastable condition immediately freezes. Hence the heavy deposits of "rime" that a cold fog leaves upon the branches of trees, telegraph wires, and the like. What is true of fog is, of course, true of clouds; the heavy strato-cumulus, the typical cloud of winter skies, consists of water, not ice. Even in the polar regions water clouds are probably commoner than ice clouds.

To what degree a droplet of water suspended in the atmosphere may be cooled without changing to ice is unknown. An observation that bears upon this question was made by Dr. George C. Simpson, a member of Capt. Scott's antarctic expedition, and was reported by him in a recent address before the Royal Meteorological Society in London. While surveying the western coast of McMurdo Sound he observed a fine fog-bow opposite the sun, with a radius of 38 degrees. The colors of this bow, and the presence of a faint supernumerary bow within it, proved it to be a rainbow (i. e., due to water drops), and not a halo (due to ice crystals). The temperature of the air at the time was 21 degrees below zero Fahrenheit, i. e., 53 degrees below the freezing-point! A further proof that the fog consisted of water was that the hair of sweaters and fur bags became covered with rime. Ice needles in the air could not have formed such a deposit.

From this observation Dr. Simpson draws some interesting conclusions concerning certain familiar optical phenomena of the atmosphere. One of the commonest of "photometeors" is the corona—the ring of prismatic colors, usually smaller than a halo, seen around the sun or moon when shining through thin clouds. The corona is an effect of diffraction, and it has been universally supposed that the diffracting bodies may be water drops, dust, or ice crystals. According to Pernter's great treatise on atmospheric optics, the best-developed and most beautiful coronæ occur in ice clouds. Pernter appears to have been misled by the assumption that the high clouds in which the finest coronæ are seen must consist of ice on account of their low temperature, but Simpson has shown that this is not the case. In fact, Simpson's observations throw doubts upon one of the fundamental assumptions of meteorology; viz., that cirrus and cirro-stratus clouds are always ice clouds. The optical theory of the supposedly ice-formed corona, as developed by Pernter, contains some striking fallacies, and that these were not pointed out before the year 1912 is a very good illustration of the fact that meteorological optics is a sadly neglected subject. Simpson appears to have shown conclusively that the corona is *never* produced by an ice cloud. That the higher clouds give the finest coronæ is explained by the fact that such clouds, when composed of water, are made up of comparatively small and uniform drops. Ice clouds will produce halos, but never coronæ; hence the constitution of a cloud may be determined from the kind of optical phenomena it exhibits.

Another diffraction effect seen in clouds is known as "irization," and the clouds that exhibit it are said to be "iridescent." This consists of patches of color seen at various distances from the sun, differing from halos and coronæ in showing no signs of concentricity, but rather following the outline of the cloud. As a phenomenon of diffraction, irization must, according to Simpson, be due to water clouds and never ice clouds.

Simpson does not mention a third kind of clouds; viz., those formed of dust. These undoubtedly exhibit both coronæ and irization. The largest species of corona—Bishop's ring—is seen in clouds of volcanic or cosmical dust at enormous heights in the atmosphere, miles above the ordinary cloud levels. After the eruption of Krakatoa such dust clouds also exhibited striking irization.