

THE OPEN MIND

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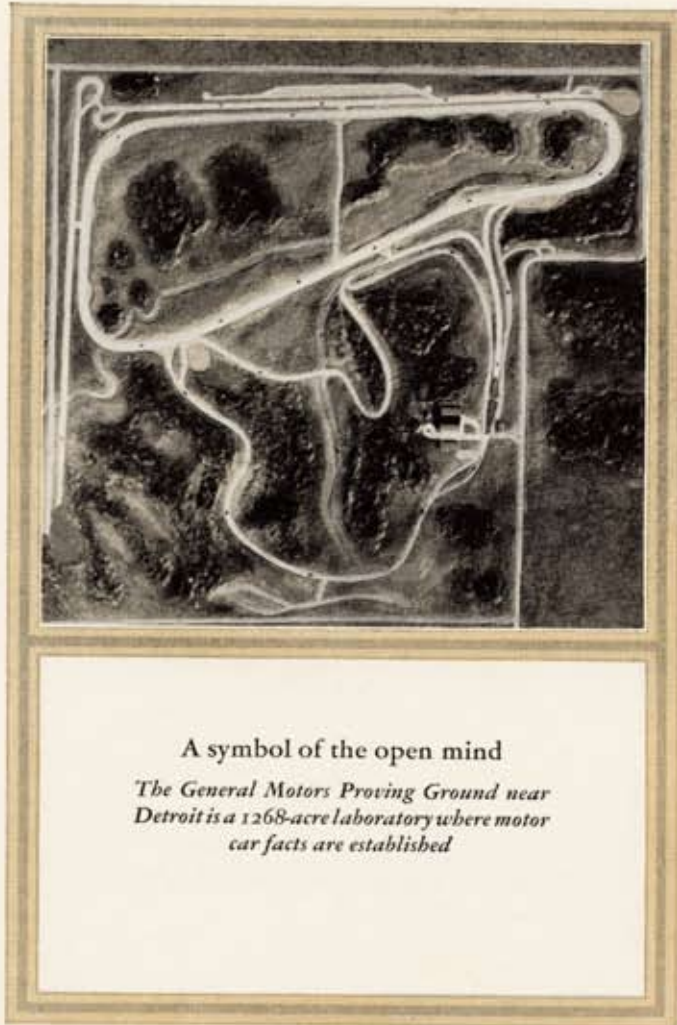
GENERAL MOTORS

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THE
OPEN MIND

... being the story, told by interesting examples, of how General Motors seeks and discovers facts... tests and uses them with an open mind

GENERAL MOTORS



A symbol of the open mind
*The General Motors Proving Ground near
Detroit is a 1268-acre laboratory where motor
car facts are established*



THE OPEN MIND

A FEW years have moved the human race from the stagecoach to the flying machine and automobile. In those years have lived many of the pioneers of progress. Others are at work for you today.

In General Motors there are thousands of engineers and scientists, able manufacturers, craftsmen, and alert members of distributing organizations who not only satisfy your present needs but anticipate those of the future. They are not bound down by yesterday's prejudices; they know that "today's best is not good enough for tomorrow." Their job is to get new facts that may be passed on to the public in the betterment of the quality, performance, service, and value of General Motors products. To their credit they have a long list of brilliant achievements.

The Research Laboratories and the members of the General Motors Family have co-operated in extensive research and development work on the self-starter, Ethyl gasoline, chromium plating, and crank-

case ventilation. Research in the laboratories and factories has improved every part of the truck and automobile.

Who Abolished Cranking?

How is it, for instance, that the inconvenience of cranking an automobile by hand, with the risk of breaking an arm, has been removed from motoring? The reason is that some eighteen or twenty years ago a young engineer had the idea that automobiles could be made to start themselves!

His idea was ridiculed. "No small storage battery can ever be made to furnish enough power to start an automobile," people said. Even the makers of storage batteries said it couldn't be done.

The young engineer believed it could be done. He wasn't sure. In a barn in Dayton he went into this problem which his imagination had set for him, with an open mind. Days and nights, Sundays and holidays, in the face of innumerable discouragements, he toiled, building and tearing apart, rebuilding, experimenting, and testing. There were times when all he had left after months of patient work was his enthusiasm—and faith.

At last, one day in 1911, he walked into the office of the Cadillac Motor Car Company and said he had an electric self-starter which would start the engine by pressure on a small pedal. Cadillac engineers made careful, unprejudiced tests of the new device in their factories.

But the young engineer had not yet reached the goal toward which he had striven so long. One day his experimental car slid off the road and, in the crash, his leg was broken. As in the case of so many pioneers,

nature herself seemed leagued against him. That very night the garage in which was the Cadillac test car, fitted with his self-starter, burned to the ground.

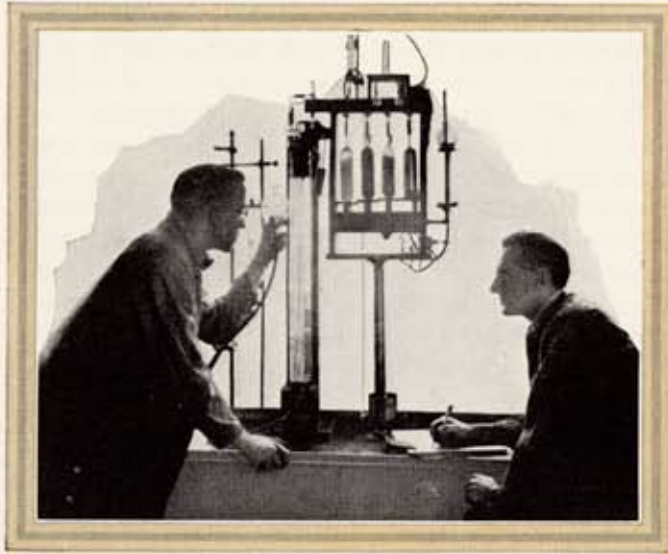
If all the progress which had been so painfully won up to that time were not to be lost, some one would have to put the self-starter in commission again, so that the tests at Cadillac could continue. Two days after his leg had been broken this young engineer actually got up out of bed, rode 200 miles on a train, flattened himself on his back beneath a car, and worked until he had his self-starter in order again. And the next year—1912—Cadillac cars were equipped with self-starters.

The young engineer who abolished cranking was Charles F. Kettering, and he is today one of the leading executives of General Motors, makers of *Chevrolet, Pontiac, Oldsmobile, Oakland, Buick, La Salle, Cadillac, Fisher Bodies, General Motors Trucks, Yellow Cabs and Coaches, Frigidaire, Delco-Light*, and many other products. He is the general director of the Research Laboratories.

The story of patience, perseverance, discouragement, and final triumph which lies behind the self-starter is not an unusual one in the world of research. In fact, it is mentioned here because it is typical of many, many others.

What is that "Knock?"

EVERYBODY has heard that metallic "ping-ping" which occurs when an automobile is laboring up a hill or on a heavy road—or is called upon for quick pick-up. Everybody knows, too, that it is accompanied by loss of power and engine sluggishness.



Why does one kind of gasoline behave better than another? Seeking the answer, chemists examine a small amount of fuel taken out of the fiery stomach of the engine

Since the knock became more pronounced about the time the self-starter and battery ignition were first used, the popular guess was that they were to blame. But General Motors wanted *facts*, and set out to find the cause of the “knock,” with an open mind.

Years of experiment finally proved that neither the starting system nor the engine was responsible. The secret of the “knock” lay hidden in the gasoline itself.

Research chemists thereupon set for themselves a new task—to find out whether there was something to mix with ordinary gasoline that would control the combustion, keep it steady, and eliminate the “knock.”

They tried thousands of different compounds without success. It looked hopeless, but they did not stop. They tried again and again until they made Ethyl fluid, which, when mixed in small quantities with gasoline, governs the explosions and eliminates the knock. Besides this, Ethyl gasoline—product of the open mind—has increased power and pick-up . . . has made possible present day high compression engines.

What Happens Inside a Closed Cylinder?

THE development of Ethyl gasoline was a milestone, but only a milestone. The study of what happens in the fiery stomach of an automobile engine still goes on. Using some of the facts discovered in the search for Ethyl fluid, the research engineers are improving fuel performance even more. Patiently and slowly, seemingly endless tests are made of gases and fuels burning inside the cylinder and being discharged through the muffler.

General Motors scientists have made instruments which, figuratively, enable them to look through the walls of a cylinder and to determine what happens in that fraction of a second it takes an engine to fire. They have devised ways of studying the composition of exhaust gas at every stage of combustion.

When gasoline and air burn in the cylinder, an explosion, or chemical reaction, takes place. What sort of explosion will produce the most power, the greatest acceleration, and the greatest number of miles per gallon? Research engineers do not expect to find the answers to all these questions today or tomorrow, or next year. But every day they progress by gaining a small number of facts. They study something that



Panels finished in Duco are mounted on racks and exposed to the elements for years. Thus the Research Laboratories prove the durability of Duco under the action of sun, wind, rain, snow, dirt from city streets, and soot from near-by chimneys

occurs hundreds of times a minute, at high temperatures, and at high pressure, hidden in a closed cylinder. Like all trail blazers of science they follow this winding, difficult path with an open mind.

Duco Saves Motorists Millions of Dollars

It used to take thirty days to finish a high grade automobile body. The whole process of production was held up in the paint shop, increasing the cost of

cars to the purchaser; and the paint finish, when completed, was easily scratched and subject to rapid deterioration by the elements. The work of paint manufacturers had shown the impossibility of any great improvement by modifying paint. If the problem were to be solved a new finish had to be developed. The duPont Company tried for several years to produce a quicker drying finish of more durable beauty and longer wear. At that time they were making a finish for toys, but it was useless for the large body of an automobile, because it dried too fast.

The duPont and General Motors engineers, together, tackled the problem, and, after thousands of trials and failures, produced Duco. Oakland, a General Motors car, was the first to adopt it.

Today Duco has become an asset not merely to General Motors, but to the better grades of cars throughout the industry. The advantage to car buyers amounts to millions of dollars per year, realized in manufacturing savings put back into the car in increased quality, and in the more attractive and durable finish.

Fan Belts Improved 14,000 Per Cent

ALTHOUGH the best fan belt on the market a few years ago seemed satisfactory enough to the average driver, it did not satisfy General Motors.

The research engineers constructed a machine to run a fan belt at high tension and terrific speed, hour after hour, day after day. Under this stress the best fan belt lasted only seven hours.

The belt was strengthened, and the relentless

machine tore it to pieces in eight hours. Strengthened again, it lived nine hours—ten.

Then the engineers adopted a quite different principle of construction, producing a belt that stood the test for more than fifty hours.

Again the specifications were changed and the score was 120 hours. At this point, when most men would have been content, these men felt they were just beginning. Working with belt manufacturers, they con-

Destroying fan belts to improve them. This testing machine has improved fan belt life 14,000 per cent. A few hours of wear and tear on the machine are equivalent to several thousand miles of use on a car



structed a belt that withstood all the machine could do to it for more than 1000 hours.

An improvement of 14,000 per cent in a minor part that was considered fairly satisfactory before the testing began!

Where Engines Show Exactly What They Can Do

IN the engine laboratories where new and old devices of every kind are put to actual test, there are many machines called dynamometers. Attached to them, engines whir all day, all night, year in, year out. The dynamometers tell the exact horsepower of each engine. They reveal the facts about how much fuel it consumes, its speed, its friction losses . . . all this, of course, with the variable elements strictly controlled. Water jacket temperature is kept constant by a thermostat; fuel and oil are carefully analyzed to insure uniformity. Even room temperature and barometer pressure are religiously recorded.

In fact, no detail that enters into engine operation is overlooked. Nothing is accepted without unshakable proof that it is correct. Research men must be practical. They cannot stop with theories, or blue prints, or models. They *build* their ideas into a finished product and test its actual performance.

What Will a Car Do in Zero Weather?

CARS, out all night long in the bitter cold of a northern winter, must start and go. "How well do General Motors cars start when the engine is freezing cold?" To find out what a car in this condition will do, the Research Laboratories have a huge refrigerator where a complete car or any part may be tested with the

temperature as low as 20 degrees below zero. Engineers, dressed like polar explorers, can observe how long a storage battery will last in the most trying cold. They can find out how well electric wiring, generators, and starters function in sub-zero weather, how good the cooling and lubricating systems are in frigid climates. With a car mounted on a dynamometer, they can make their tests at any speed and load. The fact that you can start your car on a cold morning is not just luck. It is the result of such exhaustive tests as these.

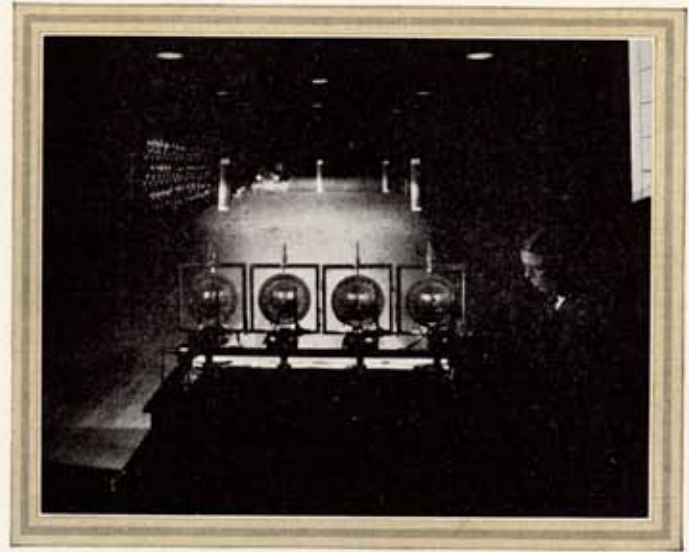
What Will a Car Do in the Tropics?

BUT the open mind is not satisfied with only the cold room tests. It wants the whole truth. It asks how automobiles will serve southern owners, under burning tropical suns. It finds the answer in the humidity room, where conditions prevailing in hot climates can be exactly reproduced.

Driving Down the Road at Night

IN the General Motors Building in Detroit there is a long, wide room where various types of headlights are tested. The problem is to get sufficient illumination for the driver to see clearly, and yet not to endanger the motorist coming from the opposite direction by blinding him with glare. Hence, many kinds and combinations of lenses are tried in the attempt to get the very best—one which will diffuse the light into a wide, flat band, send it *down* to the road, and keep the glare out of the other fellow's eyes.

The room itself looks like a road. The sides are lined with signs and test objects. At one end, facing headlights, a car is parked. With the room dark, except for



A road at night in a laboratory. General Motors scientists are working to perfect automobile lighting that car owners may drive with increasing safety and comfort. Night driving conditions are duplicated in a long dark room in the General Motors Building at Detroit

the car lights, you have to look twice to be sure you are not on a country road at night.

The adjustment of the lamp bulb in relation to the lens, the pattern made by the beam of light on the object it strikes, the change in position of the beam when the car is loaded, and the effects of poor adjustment are studied under strictly controlled laboratory conditions. Every improvement in headlights reduces the danger of accidents and adds to driving ease and safety. But, no matter how satisfactory they are, headlights will get out of adjustment, and the motorist can help himself by having them adjusted regularly.

Twisting Metal Bars Until They Break

WITH the advent of automobiles came the necessity for new and lighter metals to bear unheard-of twists, strains, pulls and shocks. Here research stepped in. Study of metal composition led to better strengthening alloys. Guesswork in heat treatment, guesswork as to how long an automobile part should remain in the furnace, had to go.

Electrical regulating and recording instruments were devised to maintain the proper temperature automatically.

How much will an axle twist? General Motors Research Laboratories are equipped with machines to test the physical properties of steel, bronze, rubber fabric, and all the materials used in a motor car. This machine determines the strength of axles and propeller shafts



In today's automobile there are at least fifteen different kinds of metals, each one adapted to the particular task it is called upon to perform. In the metallurgical laboratory, electric furnaces glow with white-hot metal, which is moulded into bars. There are giant mechanical hands which clutch the bars and pull, press, or twist them to their breaking point. One huge machine is capable of compressing or pulling with a force of a hundred tons. A torsion machine can twist an axle until it resembles a spiral stick of candy—to prove how strong it really is. These ruthless machines tell whether any metal part will be deformed or broken under a heavy load. They tell which metals should be used to insure the needed strength for automotive construction. They reveal the truth. They have no prejudice.

The Romance of an Equation

An engine is "vibrationless beyond belief," reliable brakes save a jay-walker's life, steel does not fail on roads rougher than the Rocky Road to Dublin.

Why?

Because General Motors engineers figure out in advance exactly what work every part might have to do, and build accordingly, with a generous measure of strength and quality to spare. In the Research Laboratories there are mathematicians who are building experimental cars out of figures. As wrenches are tools to a mechanic, slide rules and equations are tools to the mathematicians. They study a part and the myriad factors that affect its performance. They chart conflicting stresses and strains. They expose forces no eye can see. While to us a crankshaft is just a crank-

shaft, to them it is a piece of metal upon which certain laws of nature, almost as mysterious as life itself, obey their destiny.

General Motors saves thousands of dollars by proving *on paper* that designs are correct, for it is doubtful if the same figures could ever be arrived at by any other method.

The motorist never knows what possible trouble the advance thinking of the mathematicians has saved him.

Who says figures are dry? Is there not romance to the thought that an equation, solved months before, may be helping a fireman save a life or a doctor to arrive *in time*?

Research is Integral Part of General Motors

THE Technical Data Section is the clearing house for everything that goes on in the Research Laboratories. It is one of the important links that connect them with the manufacturing divisions. It passes on to them the facts which the research men gather. It functions, in part, as the intermediary for all of General Motors engineers.

A 1268-Acre Laboratory

AN idea or fact to be useful must stand up under exhaustive test. Knowing this, General Motors conceived and built the first and greatest outdoor laboratory, and sincerely dedicated it to progress. The Proving Ground, 45 miles from Detroit and almost equidistant from the car and truck factories, is where automotive facts are established. Like the laboratories, it is a school of automotive experience, a "facts



Ride 'im cowboy! Besides the miles of good paved and gravel roads at the Proving Ground, there are some highly uneven roads for spring tests. It was not just left to nature to make these roads bumpy. They were carefully laid out and built by engineers and are of various degrees of severity

factory." Day and night, in good weather and bad, Proving Ground engineers work without prejudice to amass the essential facts, not only about General Motors cars and trucks, but about other makes as well.

They must not guess, they must not leap to conclusions—they give every car every chance to do its best. They co-operate with the laboratories to develop precise instruments, for measuring car and truck performance. They never forget that their job is to duplicate all driving conditions that might be encountered. Daily they are taking the guess out of automotive values. They hold no brief for any car; their motto is "Show Us."

Every kind of road—mud, dirt, brick, sand, gravel (some of it tar treated), and concrete—hills with



Preparing to measure vibration. This device, the telemeter, gives Proving Ground engineers an accurate vibration record at all speeds and under all driving conditions

grades up to 24 per cent, a four-mile concrete high speed loop banked at the ends to 45 degrees, two straightaways, each a mile and a half long, and complete service garages—are some of the facilities at the Proving Ground.

Proving Ground Benefits

BESIDES putting almost every make of car and truck to more than 135 tests, and giving the information to the car manufacturing divisions of General Motors, the Proving Ground puts its facilities at the command of these same divisions, so that they may make any tests they wish upon their own products. Not only is testing taken off the public highway, where it en-

dangers human life, but the controlled conditions at the Proving Ground enable testing to be carried on *accurately* and in one-third the time, or less, that it would require on the open road.

Millions of miles of automotive experience are being gained each year and, because of the large production of General Motors, at a cost of only a few cents for each car it sells. If you buy a General Motors car, you will have the satisfaction of knowing that many just like it have passed the Proving Ground tests. Each new *design* is proved there before it is put into production.

Truly the Proving Ground is an investment that pays big dividends in service to users of General Motors cars.

Where the sky is the limit on speed! One end of the four-mile speed loop which is used for a part of the breaking-in and durability runs of each car. The other parts of the runs are made up and down steep hills of gravel, dirt, concrete and brick





An unusual test of frame distortion



How quickly will a car stop? Good brakes mean safety and this instrument, the decelerometer, gives the Proving Ground valuable information and points the way to even better brakes in General Motors cars



This 25 per cent grade at the Proving Ground will try the mettle of any car. It is many times as steep as the average highway hill

An Open Mind to New Ideas

THERE are more than 1200 engineers in General Motors; and more than twenty years of specialized experience lie behind the engineering staffs responsible for its products. It is natural that important inventions and improvements are developed inside the organization itself.

But thousands of persons of alert intelligence all over the world are busy with thoughts about automobiles, and to any one of them a good idea may come.

So General Motors has its New Devices Committee which meets frequently. It includes the head of the Patent Department, the directors of the Research



A huge magnet reveals flaws hidden beneath the surface of steel bars. Defects in metal are registered on a meter as changes in electric current

Laboratories and Proving Ground, and engineering representatives of the car divisions.

Out of the thousands of ideas and suggestions laid before it every year, relatively few can be adopted. General Motors cars must be built for service in Siberia as well as in American cities, and amid the rarified air of mountainous country as well as on burn-

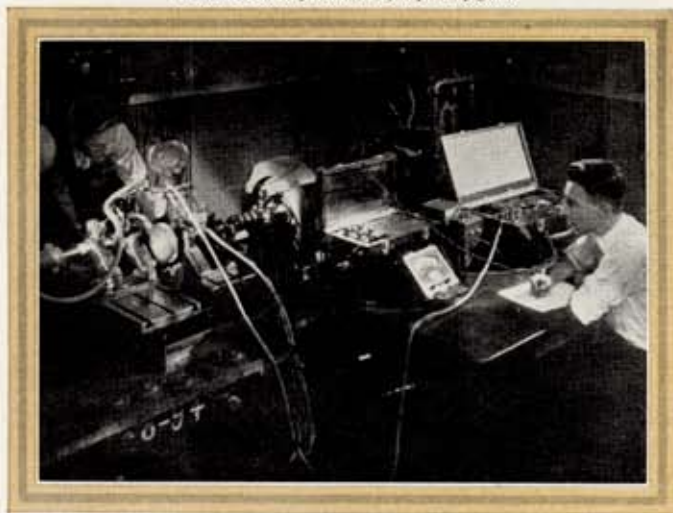
ing deserts. Many ideas that appear practical under local conditions fall down before the requirements of universal use. Many suggestions, of course, have been previously considered and found impracticable.

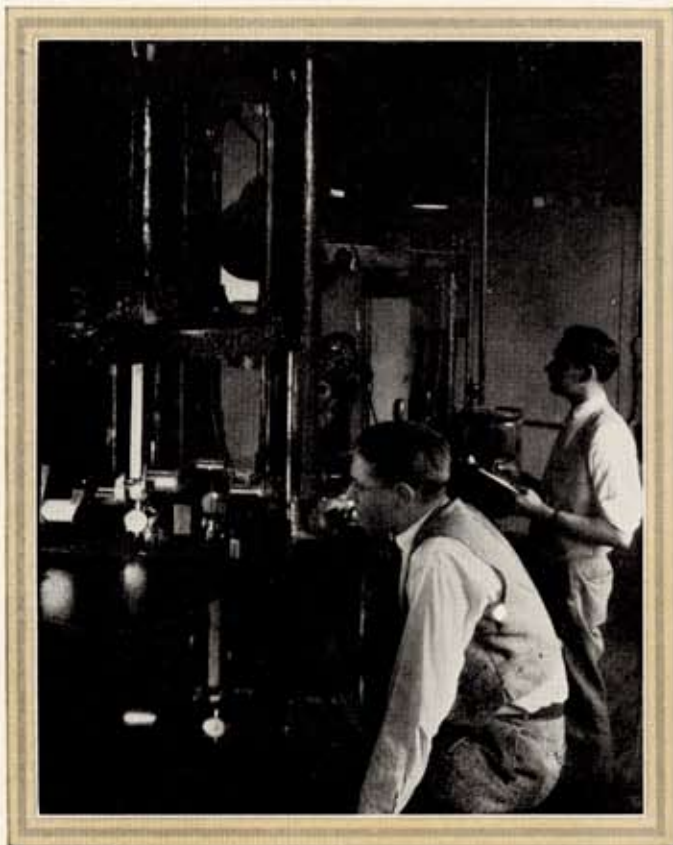
Though the percentage of usable ideas is small, the committee meets always with enthusiasm. It is part of the machinery of constant improvement in General Motors. So long as this spirit of improvement persists, an organization must keep growing; for, however old it may be in years, it will be always youthful in mind.

Frigidaire and the Open Mind

MORE than a decade ago General Motors asked: "Is there another service which can be rendered inside the

Learning how to make gears quieter. By the use of a high quality vacuum tube amplifier, similar to those used in radio sets, engineers record the noise produced by a pair of gears





Each explosion causes a slight deflection or bending of the crankshaft. The engineers measure with a high degree of accuracy the deflection which will occur in a crankshaft in service

home comparable to the service which the automobile renders outside?"

Already one division of General Motors, Delco-Light, was bringing the comfort of electric light and

power to farm homes. Electric refrigeration was in its infancy, and General Motors, acquiring Frigidaire, set its research organizations to work to improve it.

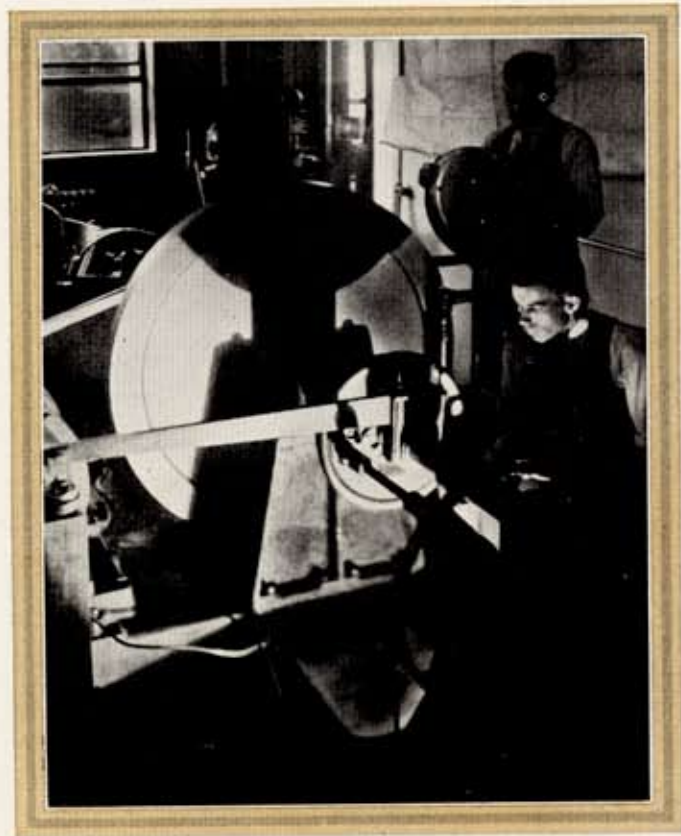
Having accomplished this, the next step was to increase production and reduce costs so that the price could be brought within the reach of every home.

To the solution of this second problem many departments of General Motors contributed. The Research Laboratories in Detroit worked with the Frigidaire Laboratories, located in Dayton. The Fisher Body Corporation was consulted in the design of the cabinets. The same engineering principles which have made automobile construction so economical were applied, for the first time, to the production of refrigerators.

Today Frigidaire is the world's largest selling automatic refrigerator. General Motors resources and experience have made it possible to produce a low priced model which is \$570 cheaper than the lowest priced model of five years ago. All over the nation—and indeed all over the world—food is better preserved and health is safer because this big problem was met with adequate resources and an open mind.

An Open Mind the World Over

IN General Motors factories all over the world, intelligent men and women are working for the people who have bought and will buy General Motors products. They are forever striving to eliminate waste, to lessen expense, and, at the same time, to improve quality. By more and more efficient production methods they are continually making savings which, often multiplied thousands of times, enable General Motors always



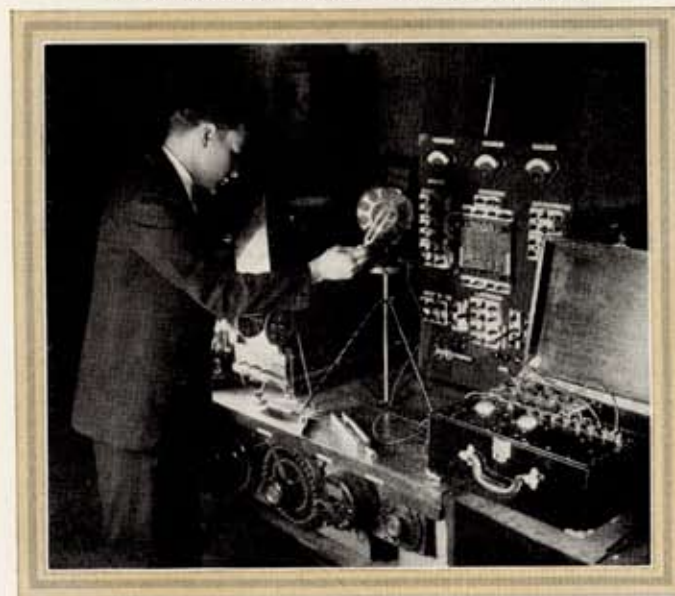
This machine tells exactly how well brakes will hold. It tests a set of brakes just as they are used on a car and definitely points the way to make brakes better and safer

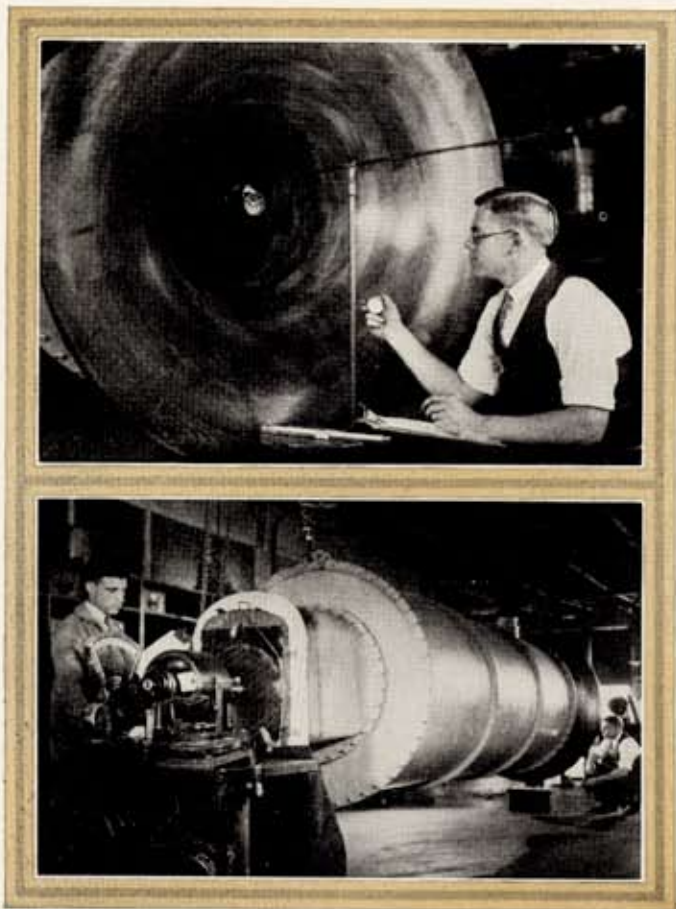
to give you more for your money. The traffic departments of the divisions, for instance, are ever finding new ways to reduce the time of shipping raw materials and the finished product.

The purchasing departments effect great economies by constructive standardization of parts and methods, by being careful to order only what will be used, and by quantity buying.

The policy of the sales departments is to give all General Motors dealers and salesmen a chance to make a just profit—not to compel them to buy cars they can't sell and which they have to sacrifice to stay in business.

Have you ever tried to locate a troublesome noise in your car? General Motors research engineers not only locate the noise, but measure exactly how loud it is and determine its frequency and general character. In this difficult work, radio is an indispensable tool





With this apparatus General Motors determines the efficiency of fans and radiators. An electric dynamometer drives the fan and measures the power it absorbs at various speeds. The fan draws air through a specially constructed wind tunnel and into the radiator



Exact information on a carburetor: Will it start a car easily? Will it feed just the right amount of fuel to the engine? Road tests are not the only answer, for the engineers also determine carburetor performance by putting a carburetor in a mercury sealed box and taking data from precise instruments

Time Payments and the Open Mind

TEN years ago there were many opinions about time payments, but few facts. General Motors began a careful study of the whole problem.

Everyone recognized the soundness of granting credit to a business—a *group* of individuals—for the purchase of necessary equipment. Was there, then, any logical reason why the *individual* should not be entitled to use his personal credit and earning power for

the purchase of a necessity, such as an automobile—just as he purchased his home or life insurance estate?

Out of this study came a General Motors policy: Every man or woman whose circumstances and income warrant the ownership of a car shall be provided with credit accommodation on a sound basis and at the lowest possible cost.

The General Motors Acceptance Corporation was organized to give effect to this policy.

Millions of families have had the use of their cars while they were paying for them, through the GMAC Plan. Sales and production of automobiles have enormously increased, resulting in much higher quality per dollar of cost.

The American people are making more effective use of their time and energies, and this has been definitely reflected in national prosperity.

The whole machinery of consumer credit has been placed upon a sound economic basis, because the problem was approached with scientific thoroughness and an open mind.

What General Motors Offers You

As a result of steadily and open mindedly getting and using all the facts, General Motors builds into its products all the value that is possible. General Motors products reflect today's best thinking, not outworn opinions or habits. They have been proved by tests, and bear the stamp of the very best modern scientific methods.

Here is what General Motors gives the buyers of its products:



Just as raindrops separate sunlight into the colors of the rainbow, so the spectroscope separates light, from hot metallic vapors, into its component colors. The spectroscope is used in the laboratories to detect minute quantities of impurities in materials, which are unmistakably seen through the eyepiece as a series of bright lines

1. Engineering Excellence—Every General Motors product embodies the best ideas of more than 1200 open minded scientists at the Engineering Departments, Research Laboratories, and Proving Ground.
2. Fair Price Policy—General Motors products offer the greatest value in each price class, which means the best cars and trucks “for every purse and purpose.”
3. High Resale Value—A large number of miles of transportation are built into each General Motors car and truck. That mileage gives the product a definite cash value which is maintained in the used car or truck market.

4. General Motors Acceptance Corporation—The largest time financing company, offering low rates on time payments.
5. Combining Purchasing Power of Many Companies—Insuring the best materials at the lowest prices.
6. Volume Production—More than 20,000 workmen are making General Motors cars and trucks at the rate of nearly two million a year, as well as millions of other products. Such volume makes quality at low price possible.
7. Finest Body Work—Fisher Body is a part of General Motors. All General Motors closed bodies are by Fisher.
8. World-wide Markets and Service—There are at least 33,000 salesrooms and service garages in more than 100 countries servicing the products of General Motors.
9. Permanence—General Motors is in business to stay. Its resources, strength, and stability assure you that the quality, service, and value of its products will be maintained and still further improved.

When you are in the market for something General Motors sells, you will do well to consider the advantages of these products of the open mind.

GENERAL MOTORS

"A car for every purse and purpose"

CHEVROLET

PONTIAC · OLDSMOBILE

OAKLAND · BUICK

LASALLE · CADILLAC

All with BODY BY FISHER

GENERAL MOTORS TRUCKS

YELLOW CABS *and* COACHES

FRIGIDAIRE, *the Automatic Refrigerator*

DELCO-LIGHT ELECTRIC PLANTS
AND WATER PUMPS

Delco-Remy Electrical Equipment · Lovejoy Shock Absorbers · Blossom Locks · Harrison Radiators · Jacox Steering Gears · AC Spark Plugs · AC Speedometers · AC Oil Filters · AC Air Cleaners · AC Gasoline Strainers · New Departure Ball Bearings · Jaxon Rims, Wheels and Tire Carriers · Brown-Lipe-Chapin Differentials · Hyatt Roller Bearings · Inland Steering Wheels · Klaxon Horns

General Motors passenger cars, Delco-Light electric plants and Frigidaire automatic refrigerators may be purchased on the GMAC Payment Plan