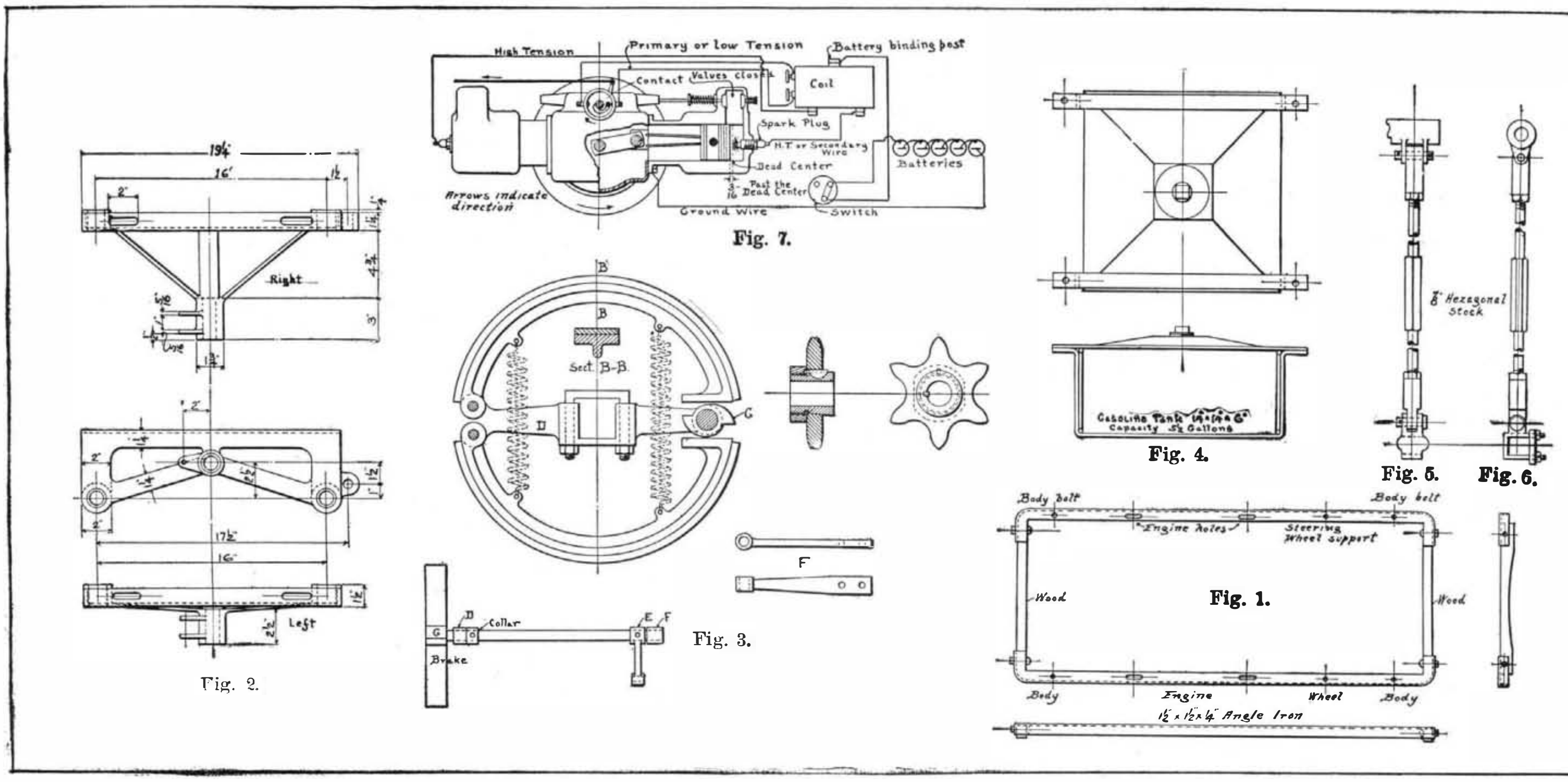


DETAILS OF MOTOR BUGGY PARTS.

Fig. 1.—Angle iron frame with wood spring bars. Fig. 2.—Plan and elevation of engine hangers. Fig. 3.—Expanding brake sleeves and operating rod. Fig. 4.—Plan and end view of fuel tank. Figs. 5 and 6.—Plan and side view of radius rods. Fig. 7.—Wiring diagram for engine.

be driven by leather or spring-wire belt from a pulley on the crankshaft.

Radius rods are made from ⅞-inch hexagon stock, turned down as in Figs. 5 and 6, and with right and left threads cut on the ends, so that they can be lengthened or shortened by turning.

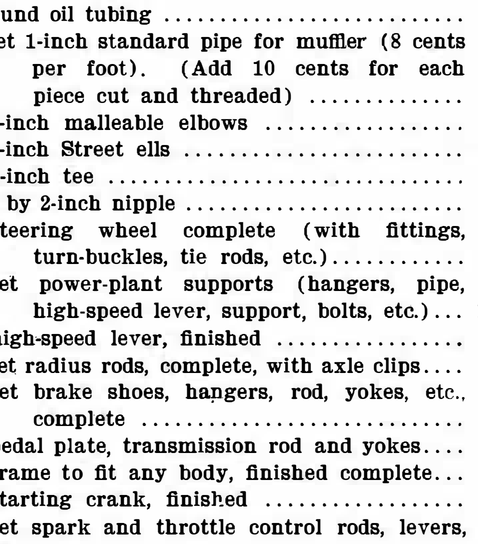
A two-speed planetary transmission is used, which also has a reverse gear. The band nearest the flywheel gives reverse motion, and the other is for first or slow speed ahead. High speed is controlled by a lever on the side, which, when pushed forward, locks all the gears, the transmission turning as a unit, so that the drive is direct at the same speed as the engine. First speed and reverse are controlled by pedals, which, when pushed forward, tighten the friction bands around the drums on the transmission. The bands should be free of the drums when the car is not running. Otherwise the machine will have a tendency to creep forward or backward when the engine is running and the gears are not engaged, according to which band is dragging, and the bands will wear out rapidly. The pedals are held in plates screwed to the floor of the car in front of the seat, and have ratchets to hold them in position when set. The brake pedal is held in the same way. The footboard must be sawed away to receive the plate at just the proper distance from the seat to be comfortable in operation, and care must be taken to have the pedals come in exact line with the transmission bands, otherwise there will be a tendency for the rods to pull the bands sidewise, so that they will not hold securely and will wear unduly.

All the necessary parts and materials for transforming a buggy as described, and equipping complete, can be bought ready made at a total of $283.57, as itemized herewith:

1—2-cylinder spark coil	$14 00
1—switch	70
2—standard spark plugs	2 68
1—6½ x 12-inch muffler	7 50
5—dry cell batteries	2 00
6—battery connections	20
6—secondary copper terminals	15
6—primary copper terminals	20
20 feet primary wire	2 80
10 feet secondary wire	3 00
1—pair side lamps	5 00
1—tail lamp	5 00
1—set of lamp brackets	3 00
1—4½-inch horn	4 00
1—gallon can lubricating oil	1 40
1—pound can of cup grease	30
1—⅛-inch brass grease cup	26
1—oil gun	60
1—small oil can	30
1—box assorted cotter pins	25
1—box assorted lock washers	60
1—tool kit	8 00
1—rear wheel brake drum	4 25
1—¾-inch pitch ½-inch wide 60-tooth roller chain sprocket	10 20
1—countershaft sprocket hub	2 00
1—¾-inch pitch, ½-inch 9-tooth roller chain sprocket	50
6 feet ¾-inch pitch, ½-inch roller chain, $1.17 per foot	7 02
2 feet 1-inch pitch, 5/16-inch block chain	86
1—1-inch pitch 5/16-inch 6-teeth ⅝-hole sprocket	36
1—6-horse-power double-opposed air-cooled motor	85 00
1—6-horse-power transmission	32 00
1—4-feed force-feed oiler, pulley and belt	15 00
½ pound oil tubing	60
3 feet 1-inch standard pipe for muffler (8 cents per foot). (Add 10 cents for each piece cut and threaded)	24
2—1-inch malleable elbows	20
2—1-inch Street ells	20
1—1-inch tee	15
1—1 by 2-inch nipple	10
1—steering wheel complete (with fittings, turn-buckles, tie rods, etc.)	15 00
1—set power-plant supports (hangers, pipe, high-speed lever, support, bolts, etc.)	18 00
1—high-speed lever, finished	75
1—set radius rods, complete, with axle clips	6 00
1—set brake shoes, hangers, rod, yokes, etc., complete	6 00
1—pedal plate, transmission rod and yokes	5 00
1—frame to fit any body, finished complete	7 00
1—starting crank, finished	75
1—set spark and throttle control rods, levers, etc.	1 25
1—pound copper tubing, for gasoline	1 20
1—gasoline tank, holding about 3 gallons	2 00
Bolts and screws at any hardware store.	
	$283 57

SCRAPING CARBON FROM THE PISTON HEADS.

Carbon is deposited in the combustion chambers of all automobile engines by imperfect combustion of the cylinder oil and gasoline. Dust from the road, drawn into the engine, adheres to the oily surfaces, and adds to the accumulation. On the piston heads, and sometimes elsewhere as well, this deposit in time becomes so thick as to be raised to incandescence, so that it causes premature ignition of the charge. It may usually be removed from the piston head by the use of long scrapers, as illustrated. These scrapers are made of ¼-inch or 5-16-inch soft steel, with the ends flattened in the forge and bent hoe-shaped. By suitably bending the shanks and by turning the crank to bring the piston into an accessible position, it is usually possible to detach all the carbon on the latter. Kerosene is used to soften the carbon, and a small battery lamp connected to a length of cord, aided by a flat dentist's mirror, enables the whole interior of the combustion chamber to be explored with ease. The material detached is scooped out clean with the piston at its highest point.



HOW THE CARBON IS SCRAPED FROM THE PISTON HEAD.

RELINING THE BRAKE SHOES.

There is more to the care of the brake shoes than simply keeping them in proper adjustment. By degrees the materials of the friction surfaces wear away, and the toggle or other mechanism by which the brakes are expanded or contracted reaches the limit of its efficient movement. It then becomes necessary to reline the brakes, or to provide new brake shoes, according to the nature of the friction material. Usually the brake drum is a steel casting, but the shoes may be fiber, cast iron, bronze, or mixtures of asbestos, camel's hair, copper, and the like. It is easy to tell what to do when replacements become necessary. The important point is to bear in mind that adjustment cannot be indefinitely repeated before the brakes become ineffective.

WHEN A LOST NUT CANNOT BE REPLACED.

There are various roadside expedients possible when a nut has been lost and no duplicate is at hand. Usually as good a plan as any is to wind the threads of the bolt tightly with soft iron wire, such as stovepipe wire, of which a coil should always be carried in the tool locker. The winding should start at the end of the bolt, and follow the threads up to the part it is desired to retain. The wire is then wound back in a second layer over the first, and the ends twisted together. If there is a hole in the bolt for a cotter pin, one should be inserted, and the ends of the wire twisted around it, so that the improvised "nut" cannot screw itself off from the bolt.

GETTING HOME WITH A WEAK BATTERY.

When a storage battery is exhausted, no more current can be obtained from it until it has been recharged, which should be done at once. A dry battery, on the other hand, weakens gradually. If one gets out on the road and the engine starts to miss after running a few miles, he may get to the next town sometimes by slightly adjusting the trembler contacts, sometimes by adjusting the tremblers themselves to bring them a little closer to the magnetic core beneath them, and sometimes by bending the spark-plug points a little closer together, so that the spark has a smaller gap to jump. If these expedients fail, the pitch may be dug out from the tops of the cells, and water poured in until the cells are saturated. If salt is at hand, salt water is better.

A HANDY TESTING CHART.*

WHAT TO DO WHEN THE ENGINE STOPS.

Arranged for the Scientific American by

ROGER B. WHITMAN,

Technical Director of the New York School of Automobile Engineers.

EFFECTS OF TROUBLE.

- **Engine will not start.** — Test ignition and carbureter. — Slow cranking or cold weather will interfere with the proper formation of the mixture. — Prime cylinders with gasoline in cold weather to obtain mixture for starting. — To increase suction in carbureter, prevent operation of air-valve.
- **Engine starts, but will not continue running.**
  - Fuel does not flow freely to carbureter.
  - Weak battery.
- **Engine runs well slowly, but misses when speeded up.**
  - Worn timer.
  - Weak battery.
  - Faulty vibrator adjustment.
  - Faulty carbureter adjustment.
  - Fuel does not flow freely to carbureter.
- **Irregular miss.**
  - Slipping timer.
  - Loose half-time shaft.
  - Sticking air-valve.
  - Intermittent obstruction in spray nozzle.
  - Sticking valve.
  - Broken or weak valve-spring.
  - Loose connection.
  - Short circuit.
- **Engine will not run slowly.**
  - Weak magneto.
  - Faulty carbureter adjustment.
- **Explosions cease abruptly.** — Break in ground wire, battery connections, switch lead.
- **Engine will not stop.**
  - Preignition.
    - Glowing carbon or metal point in cylinder.
  - Engine too hot (see Cooling trouble).
- **Engine noises.**
  - Knocking.
    - Too much retard of spark.
    - Preignition.
    - Worn bearings.
    - Loose or cracked flywheel.
  - Hissing.
    - Broken piston rings.
    - Leaking air inlet pipe or gasket.
  - "Popping" in carbureter.
    - Leaking inlet valve.
    - Weak mixture.
    - Excessive retard of spark.
- **Steady miss in one or more cylinders, (other cylinders firing normally).** — Vibrator, timer, secondary circuit.
- **Engine does not deliver full power.**
  - Faulty setting of valves.
  - Tight bearings or broken balls. — Indicated by excessive heating
  - Back pressure. — Fouled muffler.
  - Dragging brakes.
  - Friction in transmission.
  - Faulty carburetion.
  - Weak ignition.
  - Weak compression.
  - Overheating.
- **Explosions weaken and cease.** — Carbureter or fuel trouble.

IGNITION. Jump spark with single coil, battery secondary distributor.
- Test primary circuit as described for system using coils and timer.
- Secondary may short circuit from
  - Fouled or worn distributor.
  - Defective insulation

IGNITION. Jump spark, with battery, timer and coils.
- To test, revolve crank-shaft twice, listening for vibrator.
  - All vibrators sound normal, primary circuits O. K. unless timer has slipped on shaft. — Vibrator should begin to operate as a piston gets to top center of compression, with spark lever retarded.
  - One or more vibrators sound normal, showing that battery connections, lead and ground wires, and battery are O. K. — To test coils, short circuit the timer by making contact between primary terminal of coil and ground.
    - Vibrator normal, coil is O. K., look for — Interruption in timer circuit.
    - Blade moves, but will not vibrate.
      - Punctured condenser (a).
      - Short circuit at vibrator.
    - Vibrator does not operate.
      - Faulty adjustment.
        - Too stiff. — Will operate only with strong battery.
        - Too weak.
          - Excessive sparking at vibrator, and battery exhausts rapidly.
          - Feeble secondary spark; misfiring with slightly corroded contacts.
      - Contacts corroded.
      - Contacts stuck.
  - Vibrators do not operate.
    - Open switch; vibrator trouble.
    - Trouble in battery or in primary circuit. — To test, make momentary contact from switch terminal to ground.
      - Bright spark, battery lead and ground wire O. K.
      - Weak or no spark.
        - Break in battery connections, lead or ground wire.
        - Battery exhausted or dry cells polarized.
- **TEST 1. Alternate test, prime cylinders with a few drops of gasoline, close relief cocks, and crank. Explosions show ignition to be O. K.**
- To test secondary, disconnect spark plug leads, support them ⅜ inch from engine ground and crank.
  - Good spark, O. K.
  - Weak spark.
  - No spark.
    - Vibrator trouble.
    - Plug short circuited, fouled, oily.
    - Points too far apart—should be 1/32 inch.
    - Short circuit in secondary.
    - Broken condenser connection (a). — Shown by brilliant sparking at vibrator.

IGNITION. Make and break, with low tension magneto.

Use Test 1, cranking briskly.
- Explosions.
  - Ignition O. K. unless
    - Magneto is out of time and igniters incorrectly adjusted. — Should break circuit at top center of compression when spark is retarded.
- No explosions.
  - Short circuit.
    - Insulated bridge on magneto.
    - Switch or switch lead.
    - Bus-bar or bus-bar lead.
    - Igniter insulator broken.
    - Igniter stuck closed.
  - Open circuit.
    - Broken spring.
    - Tappet stuck in guide. — To test operate by hand.
  - Magneto broken down.
    - To test magneto, disconnect magneto lead from bus-bar and hold free end in bare fingers, or
    - **TEST 2. Hold free end against teeth of metal gear and crank briskly.**
      - Shock or spark. — Magneto O. K.
      - No shock or spark.
        - Fouled collecting brush.
        - Armature burned out (a).
        - Fields demagnetized (a). — To test, unmesh gear, revolve armature by hand. If fields are O. K., armature should turn perceptibly hard twice in each revolution.

CARBURETER. To test, hold lighted match over open relief cocks while engine is cranked briskly.
- Mixture ignites — Proving that carbureter is doing its duty.
- Mixture does not ignite. Operate primer to flood float chamber.
  - Gasoline drips from spray nozzle.
    - Mixture too rich.
      - Insufficient air.
        - Faulty adjustment of air valve.
        - Clogged inlet pipe.
        - Dust on inlet pipe screen.
      - Leaking float valve.
      - Float too heavy.
        - Soggy (if of cork) (b).
        - Punctured (if of metal) (c).
      - Faulty adjustment of float.
    - Mixture too poor.
      - Too much air.
        - Faulty adjustment of air-valve.
        - Leaks in inlet pipe.
      - Water in gasoline.
      - Faulty adjustment of float
  - No drip from spray nozzle.
    - Clogged spray nozzle.
    - Clogged float valve.
    - Clogged fuel feed.
    - No gasoline.
    - Empty tank.
    - Closed supply cock.

IGNITION. Jump spark with low tension magneto and coil (Eisemann, Remy, Splitdorf, etc.) — Proceed as in Test 1, cranking briskly.
- Explosions. — Ignition O. K. unless magneto is out of time. Should be reset.
- Sparks in safety spark gap.
  - Interruption in secondary circuit.
  - Too wide a gap at plugs (should be from 1/64 to 1/32 inch).
- No explosion.
  - Primary circuit open.
  - Primary short circuit.
  - Magneto broken down. — To test magneto, disconnect primary lead to coil and proceed as in test 2.
    - Shock (or spark), magneto O. K.
    - No shock (or spark).
      - Interrupter short circuited, wet or oily.
      - Field demagnetized (a).
      - Condenser broken down (shown by brilliant spark at interrupter) (a).
  - Coil broken down.
    - To test primary winding of coil disconnect ground wire and proceed as in second part of test 2.
      - Spark, winding O.K.
      - No spark. — Winding broken (a) down or short or open circuited.
    - To test secondary winding of coil, disconnect spark plug leads from magneto and crank briskly, watching for sparks at safety spark gap.
      - Sparks, look for
        - Plugs short circuited.
          - Fouled.
          - Insulation broken down.
          - Fused metal bead at points.
        - Secondary short circuit (a)
          - Leads short circuited.
        - Ground circuit open.
      - No sparks, winding broken down.

IGNITION. High tension magneto (Bosch, U. & H. Lacoste, Witherbee, etc.) — Proceed as in Test 1, cranking briskly.
- Explosions. — Ignition O. K. unless magneto is out of time. Should be reset.
- Sparks in safety spark gap.
  - Break in secondary circuit.
  - Too wide a gap at plugs (should be 1/64 to 1/32 inch)
- No explosions. — To test magneto, disconnect spark plug leads from distributor and crank briskly, watching for sparks at safety spark gap.
  - Sparks.
    - Magneto O. K.
    - Look for short circuits in
      - Spark plugs.
        - Fouled.
        - Insulation broken down.
        - Bead of fused metal between points.
      - Switch lead.
      - Switch.
  - No sparks.
    - Corroded interrupter contacts.
    - Interrupter stuck.
    - Armature burned out (a).
    - Condenser broken down (a).
    - Field demagnetized (a).

FUEL FEED SYSTEM. To test, open drain cock at carbureter.
- Gasoline flows. — System is O. K.
- Gasoline does not flow.
  - Gravity feed.
    - Clogged vent hole in filling cap.
    - Clogged piping (d).
  - Pressure feed.
    - Sufficient pressure in tank. — Clogged piping (d).
    - Insufficient pressure in tank.
      - Leaking tank or piping.
      - Leaking filling cap.
      - Stuck relief valve.

COMPRESSION.
- To test, crank engine slowly, noting resistance, which should be the same in all cylinders. (Do not confuse constant mechanical resistance with intermittent resistance of compression).
- Inject oil into faulty cylinder.
  - Improved compression indicates
    - Stuck piston rings. — Dose cylinder with kerosene and alcohol ½ and ½ to cut carbon.
    - Worn or scored piston rings.
    - Scored cylinder walls.
  - No improvement in compression indicates
    - Worn or pitted valves.
    - Leaking spark plug, igniter plate, relief cock, etc. — Test by running oil around these and cranking. — Leak indicated by bubbles.
    - Piston ring splits in line.
    - Broken piston rings. — Crank case will be abnormally warm.
    - Cracked walls or head. — Indicated by water in cylinder.
    - Sticking valves.
    - Insufficient space between valve stem and push rod.

COOLING (Water.) — Radiator should heat evenly shortly after engine is started.
- Radiator does not heat.
  - Clogged circulation system.
    - Empty tank.
    - Clogged piping.
    - Defective pump.
  - Test by opening pet cocks.
- Radiator steams.
  - Failure of lubrication. — Indicated by groans from cylinders affected. — Supply should be just sufficient to produce faint whiff of blue smoke at exhaust.
  - Defect in circulation.
  - Too much running on retarded spark or on low speed.
  - Slipping fan drive.

* It is taken for granted that the engine is capable of running properly, that the tanks are filled, and that the switch is correctly thrown.

(a) Return to makers for repair. (b) Dry in oven, and coat with shellac. (c) Plunge in hot water to expel gasoline and to locate leak. Repair with solder. (d) May be cleared with blast from foot pump.

A TALK WITH FLANDERS

AN INTERVIEW WITH A FAMOUS AUTOMOBILE MANUFACTURER

WALTER E. FLANDERS, of the Everitt-Metzger-Flanders Company, of Detroit, Mich., who, more than any other man, has been instrumental in making an "industry" out of what, until recently, was called the Automobile "Game," gives an insight into the methods which have placed within the reach of thousands, at a price they can afford, a car such as $2500 could not have purchased one year ago.

"A BETTER automobile can be built and sold for $1250 than is possible at twice that price."

This is an astounding statement—at least so it seemed to the "automobile editor," when he first heard it.

The speaker was Walter E. Flanders, General Manager of the Everitt-Metzger-Flanders Co., of Detroit, a man who is reputed to be the greatest factory organizer and producer of automobiles that industry has ever known.

Now the writer-man knew Flanders to be a very genial gentleman outside the office, but he is seldom known to joke during business hours or about business matters.

Certainly there was nothing in the expression of his face to indicate that he was trying to catch the writer by a juggling of words. Rather was his mien most serious and his tone most earnest.

Still I could not accept the statement at par. Surely, thought I, there must be a double meaning somewhere; and so I turned the words over and over; transposed them this way and that; tried to read the sentence backward as well as forward, so as to make it sound like sense and yet mean anything but the astounding fact it stated.

Flanders is a man of few words. He is a doer of deeds, and what information an interviewer gets from him must be elicited by following up question after question along the lines he desires enlightenment.

I had been reading "The First Word," a preliminary announcement of the E.-M.-F. "30" Car which is being manufactured under Mr. Flanders's direction, and the claims made therein piqued my interest.

Having charge of the "automobile column" the writer necessarily has imbibed a good deal of technical information on that interesting subject, the motor car, and a careful perusal of the specifications of the E.-M.-F. "30" seemed to bear out the startling claims of the prospectus. So I had determined to find out for myself and had come to the fountain-head for information. The opening sentence of this article was the reply to my first question.

"I give it up," I said. "What's the answer?"

Mr. Flanders smiled: "There is no answer. I meant just what I said. *A better automobile can be manufactured and sold for $1250 than at twice that price—$2500.*"

"Do you mean by that that it is possible to build a better automobile now for the lower price than it has been heretofore for twice the figure?"

"Not at all. I mean that a better car can be built at the lower figure than it is possible to build at the higher figure. Now!——"

"Reasons 'why' are in order," I said—"for if there is no answer there must be a reason why."

"There is," said Mr. Flanders. "It's a simple problem. In fact I think its obscurity lies in its very simplicity—for most people go a long way round in search of a simple fact, while the great successes are achieved by the most direct routes.

"The demand for a car at $2500 is limited. I would say that no man with an income of less than $5000 a year has any business to own a car at that price—the first cost of an excessively large, high powered car is not so much a consideration as cost of operation and upkeep. On the other hand a car of $1250 may not be considered a luxury for a man with an income of $1800—be it in the form of a salary or income from office, shop, store or other business. Such a car will necessarily be of moderate power and light weight and the tire, fuel and other items of maintenance cost will be correspondingly small.

"Having reached that point it is a simple matter of statistics to find that there are at least 500 men who earn $1800 a year for each one whose income is $5000. In other words the possible consumption of a $1250 car is fully 500 times the possible demand for one selling at $2500.

"Now in manufacturing, the first point we want to make sure of is—demand.

"For high priced cars the demand will always be limited. The manufacturer who would make sure of the future must produce a car to meet the requirements and at a price within reach of the multitude of judicious buyers—the men to whom price is an object and yet who demand high grade quality. That this is the safest policy is proven by the fact that even last year (1908) when there was so much talk of hard times, makers of moderate priced cars were all over-sold, and the high priced were the only ones that experienced a falling off in the market.

"There are at least half a million people in the United States to-day who can afford a $1250 car. It's only a question of deciding they want one. For our own purpose, a very small percentage of this number will suffice—12,000, for that is all the cars we can hope to build before October 1st, 1909, even with our splendid organization and factory facilities.

"A certain demand enables us to plan for production on an immense scale and to adopt methods that are impractical in the building of a $2500 car which must necessarily be confined to small quantities—1000 at most. Of course there is a market for several thousand high priced cars but no single maker can hope to corral it all."

"But do you mean to say," I asked, "that you can build a car of the same size and power and quality, material and workmanship both considered, for $1250 as that which can be built for $2500?"

"I said a better one," said Flanders.

"Take the E.-M.-F. '30' for example. It is a full size, 5-passenger car with wheel base of 106 inches—longer than most $2500 cars of a year ago. There is ample room for five large adults.

"The engine develops over 30 horse power—sufficient to take 5 passengers anywhere and giving more speed than should ever be used on public roads. I can show you 55 miles an hour with five up.

"In this car is incorporated every feature that is a necessary or desirable part of an up-to-date automobile—made of the best material procurable and machined better than any $2500 car you can name. I say better advisedly; for, in planning for a production of 12,000 cars we are, as I have said before, able to utilize methods which are absolutely impractical in the making of a car at $2500 when made in the limited quantities which the comparatively limited demand justifies.

"For example: Our rear axle housing is drawn from two sheets of steel—lighter and vastly stronger than the ordinary seamless-tube-and-cast-steel combination you'll find in other cars no matter of what price.

"Some twenty operations are necessary to form this housing. The cost of dies and tools for the job is $9000. Now suppose we were making only 100 E.-M.-F. '30' cars: the tool cost alone on this part would amount to $90 per car. On 1000 cars it would still amount to $9 a car. That would be prohibitive in a $5000 car."

"Do you mean to say I——" I interrupted—

"*I mean to say that if the same practice was carried throughout the entire car and it was made in quantities of only 1000 it could not possibly be sold for $2500 nor four times that price.*"

"But 12,000 cars——" I began.

"Yes I know," Flanders interrupted: "Some makers claim that 2500 cars constitute 'quantity production.' As a matter of fact it's only a beginning. If, instead of distributing our initial tool cost, of several thousand dollars, over but 2500 cars instead of five times that number—for you know we must make 500 extra sets of parts for replacements and repairs, a complete set of which every E.-M.-F. dealer must carry in stock—if this cost instead of being divided among 12,500 and had to be borne by 2500 we would have to charge $1500 to $1600 for the car, as others do and there are many reasons why we couldn't make it as good at that price in the smaller quantities as we do at $1250. The systematizing of a factory and training of a force of several hundred men till each is an expert on his own particular specialty, are problems you would hardly understand but their solution is simplified when the quantities are such that each man performs one task until he becomes expert at that one operation. But to return to the matter of tool cost which I can more easily explain to one unfamiliar with the multitudinous problems of factory organization and operation.

"Take this axle item. In 2500 lots the tool cost on this piece—and it's only one of over a thousand parts in an automobile—would be $3.60 per car. That still would be prohibitive. You never saw a $2500 car with a pressed or drawn steel axle. They are all built up of a combination of steel tubing with malleable iron casting for the differential housing—aluminum sometimes, lighter and more expensive than malleable (or 'cast steel') but also less than half as strong.

"In 12,000 cars, however, this tool item amounts to only 75 cents per car.

"Up to a certain point in manufacturing, hand methods—and the hand cannot approximate the machine in accuracy for re-duplicating parts—are less expensive than automatic machine work—taking into account of course the enormous first cost of automatic machines, jigs, tools and fittings. But just as soon as you pass that point you can inaugurate manufacuring methods which reduce the cost of every operation to a degree that is almost incredible to one not versed in manufacturing problems.

"For example: No $2500 car ever made has a cam shaft forged in one piece with eight cams integral and *the cam contours as well as the bearings* ground to absolute accuracy in size and form—yet this is a detail of the $1250 E.-M.-F. '30' car.

"This operation could not possibly be performed by hand. Automatic machinery is necessary; and as there was no such machine on the market we had to design it. When you consider that we have about 100,000 cams to grind, you will see that the cost of a $6,000 automatic machine will spread out pretty thinly over that number—less than fifty cents for each set of eight cams. That is cheaper than to mill them by the ordinary method to say nothing of its being infinitely more accurate. Now accuracy in a cam guarantees uniform power with absence of noise—because it guarantees a definite clearance between plunger and valve.

"That is just one of many details wherein the $1250 car may be superior to a $2500 one in which such methods would be commercially impractical.

"I might mention a hundred other operations where the cost is reduced at the same time that better quality is secured. Here are a few:

"24,000 twin-cylinder castings make possible the adoption of moulding machines instead of hand work. This makes for higher quality because the cylinder invariably is smoother in outward appearance and of uniform thickness throughout. Uniform thickness is another guarantee of power because the expansion under heat is uniform; it also eliminates one of the most fruitful sources of scored-cylinder troubles.

"The yokes which hold the exhaust and intake pipes are steel stampings—half the weight, twice the strength, of forgings or castings—and of course they cost less to make.

"In planning to turn and grind 48,000 pistons, an item of $10,000 for automatic machinery is a mere bagatelle—each machine will finish a piston in ten minutes, more accurately than it is possible to do on an ordinary lathe in an hour, and one man will operate four machines.

"The same pressed steel frame—same material, and same workmanship, same quality throughout that would cost $40.00 to make in lots of 2500, costs us less than half that price in quantities such as we make—another example of distributing a heavy initial tool-and-die expense over a large number of cars.

"I could take you through the entire car and show you where the labor cost is reduced 50 to 90 per cent. by quantity production as compared with making the parts in limited numbers, *and every step would show a corresponding increase of quality with decrease of cost.*

"By the use of steel stampings and pressed steel—which operations are commercially practical only in large quantities—we are enabled to practically eliminate such metals as manganese-bronze, cast-iron, malleable iron and aluminum.

"We retain aluminum for the transmission housing and engine crank-case but nowhere else."

"You discard aluminum because it costs you more?" I ventured.

"Costs us more? Not at all! It is all the same to us. It is the buyer of the car who pays the bill.

"Supposing our net profit on a machine is 10 per cent; and that the selling price is necessarily based on the manufacturing cost; you will see that if we pay 50 cents a pound for aluminum, the buyer of a car pays 55 cents a pound. Now if we are able to replace that aluminum with a steel stamping, of handsomer appearance, vastly greater strength and at a cost of say 5 cents a pound, the buyer of the car pays only 5½ cents. You cannot get something for nothing.

"No automobile manufacturer would use so weak and so uncertain a metal as aluminum if it were possible to cast a stronger metal in the same form and sufficiently thin to get the weight within reasonable limits. Unfortunately, while iron is twice as strong as aluminum, it is not practical to cast it any thinner; and a 3/16-inch wall of iron weighs just three times as much as the same thickness of aluminum. In some places—such as engine crank-case—we get sufficient strength in an aluminum casting and with the lesser weight, whereas the form precludes the possibility of stamping it satisfactorily from steel.

"For motor supporting arms, however, we use pressed steel—this is one place where aluminum has proven most unsatisfactory through its liability to frequent breakages and its inability to withstand severe vibratory stresses.

"Now in a $2500 car the cost of making dies for pressing these members would amount to more per car than the 50-cents-a-pound-aluminum—so the average maker is compelled to charge the buyer for the most expensive metal without being able to give him the desired safety factor. The cost of making the dies for the pressed steel members, though several hundred dollars, distributed over 24,000 pieces—two for each motor—is a negligible item in the case of the E.-M.-F. '30'.

"Here's another fact which may not have occurred to you: In reading over our specification sheet you doubtless noticed that we grind many shafts and other parts which you do not ordinarily find so accurately made in cars of the highest price.

"Now grinding is the most expensive operation in machining metal—but it is also the most accurate. Accuracy is economy—though not all makers seem to appreciate that fact.

"We can better afford to grind a part than to take the risk of its not fitting the other part with which it must engage. *We could better afford to grind one hundred parts than to disassemble one car to replace a noisy gear or a bearing that has seized because too tight or which is noisy because too loose.*

"Grinding is cheaper, provided the quantities justify investment in highly specialized machines for the work, than it is to buy files and pay a force of men to fit crudely machined parts. We grind to ensure facility in assembling—and the buyer gets better quality throughout. It is a selfish consideration with us, for it reduces the cost; but the customer gets the benefit of this saving as well as the greater accuracy.

"Another saving is effected in the testing of cars after assembling.

"As a matter of fact the term 'testing' no longer has an application to automobile manufacturing among men who know their business and possess the facilities to do things the modern way.

"To say that a car needs testing is to admit the possibility at least, of inaccuracy—generally, it implies a probability.

"In these days when science can tell us to an ounce the strength of a metal, the only chance for error is in the machining of a part. Eliminate that chance by machining it—reaming, grinding or otherwise—to the necessary degree of accuracy, a quarter to a half thousandth of an inch—what is there left to test?

"Watches made by the millions are never tested. They are regulated—adjusted—that is all.

"So with a properly manufactured automobile. Engine parts, axle, driving gears, bearings, may need adjustment after assembling; but testing—that implies careless work; and that is the one luxury we cannot afford in a $1250 car! It is permissible only in a car for which the customer is induced to pay a high price under the delusion that 'hand work' is superior, whereas, as a matter of fact, it is simply a process of making one error to fit another. And he pays treble every time he must replace a part by the cut-and-try process.

"You'll find a parallel for these conditions in many other commodities of everyday use.

"Detroit is the center of the stove industry, as it is the automobile center of the world. Any stove manufacturer will tell you it costs $40,000 to $50,000 to produce the first plain cook stove of any new model. Taking into account, of course, the designs, patterns, dies, jigs, tools, experimental work, and the changes that are necessary before a satisfactory product is secured—every item of which preliminary expense must be distributed pro rata over all the stoves of that model made thereafter.

"Once perfected, they turn out that stove in lots of 20,000 to 150,000 a year—and sell it for seven or eight dollars—the 'overhead' spreading thinner as the quantities increase.

"The first typewriter that would write cost over $300,000—and the man who would have paid $100 for that particular machine would better have thrown his money away. Not one part could be replaced at any reasonable figure. To-day, a highly perfected machine of that same make, a marvel of ingenuity, is manufactured for a few dollars—steel stampings and automatic machine work. The low price has made it a necessity in every office—hundreds of thousands are sold annually to persons who a few years ago did not dream they ever would need one.

"The E.-M.-F. '30' at its price has already created a demand greater than even we had expected. And this is only the beginning.

"When your father was a boy, a good rifle was a luxury few could afford. To-day you can buy a better rifle than your father ever saw for one-tenth what he would have had to pay for one made by hand. They are made by the millions now because millions can afford the price—and the demand for millions makes the adoption of manufacturing methods—and hence the low price—possible."

"But these are problems peculiar to all manufacturing, are they not?" I asked. "Why have not these methods been applied to automobile making before? Why have we had to pay twice as much for a car as it has been worth?"

"There are several reasons—three primary ones: First, until recently automobile design had not crystallized into any accepted standard. While we were still in the experimental stage, uncertain as to what features were best—sliding-gear or platenary transmissions—two, versus four cycle motors—air cooling versus water cooling; and a hundred other details, matters of dispute among designers, no maker dared turn out a large number of cars of any model—none dared anticipate the future by more than a few months.

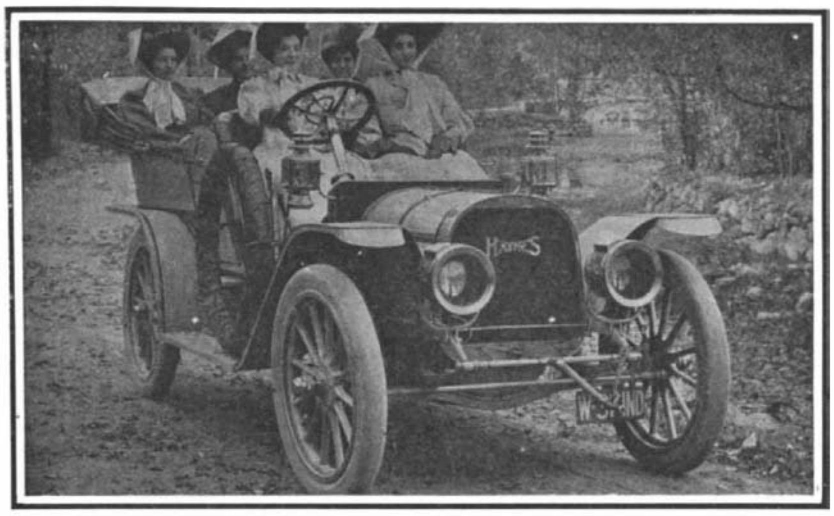
"The public—the motoring public—seems to have been alive to the conditions. The maker who would have turned out 10,000 30-horse-power, four-cylinder cars four years ago would have found no market even had he offered them at $1250.

"Anyone at all interested in the subject knows that at that time the motor car was still in the transitory state—no part had been standardized—none accepted as final. Only a few enthusiasts bought, the great conservative public waited and watched—interested, hopeful, but unsatisfied.

"It's an interesting fact that, from year to year the demand has just kept pace with—always a little in advance of—the mechanical development of the automobile.

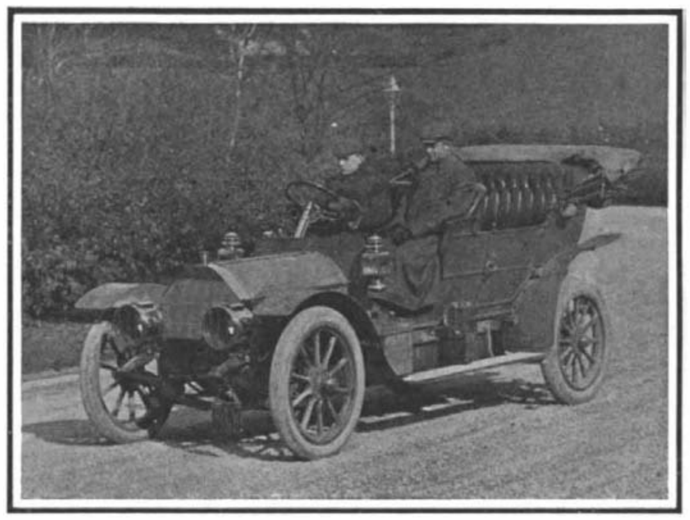
"We now have come to the place where we know what a car should be, and we find our public ready to buy—able to buy since we can produce at a price within the reach of the great moderately-rich class.

"The second and the chief reason why manufacturing methods have not heretofore been applied to automobile building is that a broad experience is necessary to equip and organize a factory for economical production on a large scale. The automobile business can boast of few men with the proper training. Most of the engineers have grown up with—been developed by, the growth of this industry. And they are unable to rise above their experience."



Wheel base, 112 inches; 36 horse-power; 4 cylinders, $4\frac{3}{4}$ x 5 inches; cellular radiator; dry battery and high-tension ignition; contracting band clutch: selective sliding gear transmission with three speeds forward and one reverse; shaft drive.

Haynes touring car.

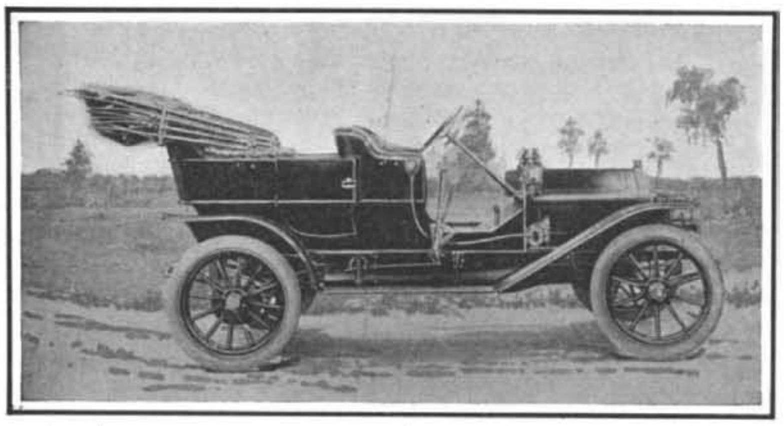


36 horse-power; wheel base, 119 inches; 6 cylinders $3\frac{15}{16}$ x $4\frac{3}{4}$ inches; cellular radiator; storage battery and high-tension ignition; cone clutch; selective sliding gear transmission with four speeds forward and one reverse; shaft drive

The Pierce "Arrow."

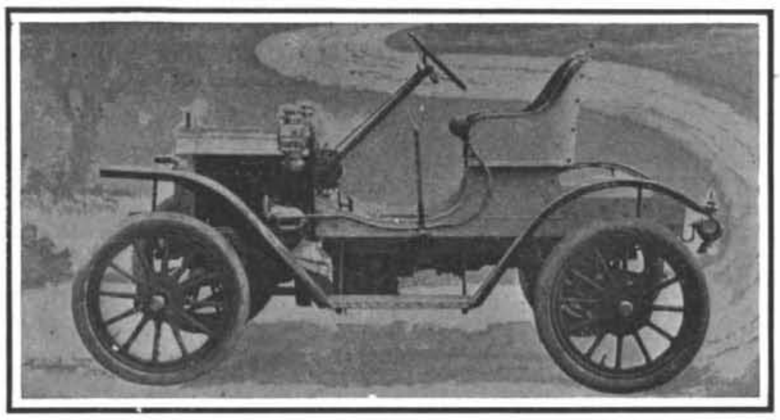
34 horse-power; 4 cylinders. A feature of the 4-cyl
except for the hub center, and carrying a tire infl
hub center by six bolts. The spare wheel can be

Rambler tourin



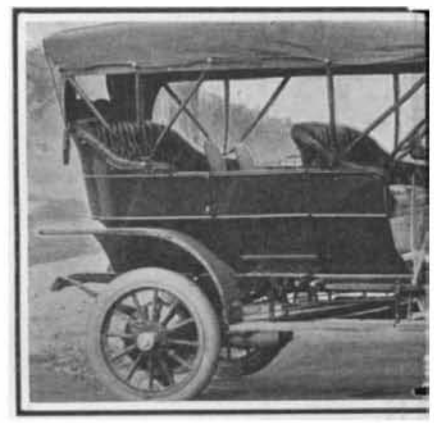
Wheel base, 106 inches; 4 cylinders, 4 x $4\frac{1}{2}$ inches; vertical tube radiator; dry battery and high-tension magneto ignition; expanding ring clutch; selective sliding gear transmission; three speeds forward and one reverse; shaft drive.

Everitt-Metzger-Flanders 30-horse-power touring car.



7 horse-power motor; 4 x 4 inch single cylinder; planetary transmission with multiple disk clutches. Drive: Bevel gear to jack shaft and double side chains to rear axle. Coil spring with friction joint radius rods. Maximum speed, 30 miles an hour.

Brush runabout.

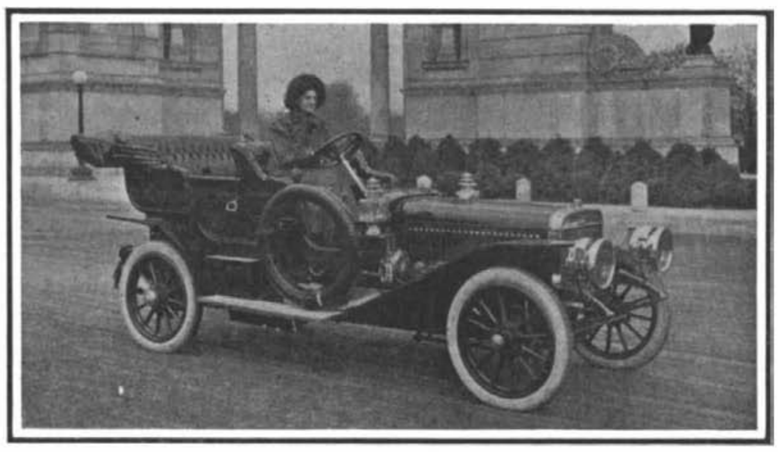


4 cylinders; 45 horse-power; speed, 3 to 50 mile
unit coil; storage battery: high-tension magneto
Selective sliding gear transmission. Three

Glide tourin

High-pressure cylinder, $2\frac{1}{2}$ x 3 inches; low-pressure cylinder, $4\frac{1}{4}$ x 3 inches. Joy valve motion actuated from connecting rods; pumps driven by levers of the valve mechanism.

White steam car. 20-horse-power touring car.

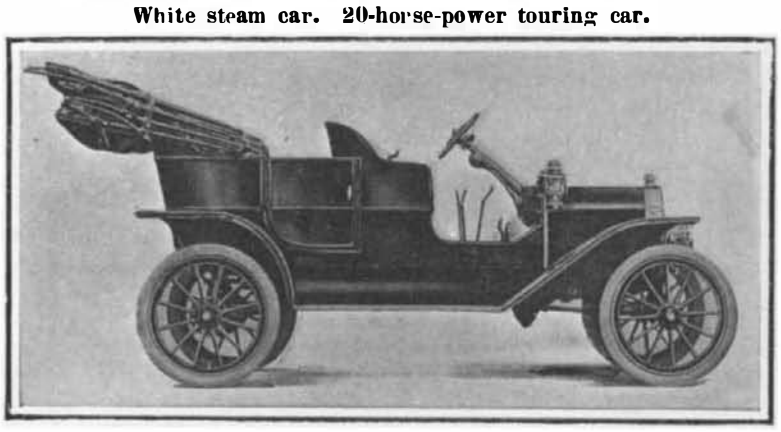


48 horse-power; 6 cylinders, vertical tube radiator; dry battery and high-tension magneto ignition; multiple-disk clutch; selective sliding gear transmission; shaft drive.

Winton five-passenger car.

4 cylinders; water cooled; make-and-break
type change gear; three speeds forw

Premier 30-35 horse-



Wheel base, 100 inches; 4 cylinders; spur planetary transmission; low tension magneto ignition; vanadium steel springs, axles, shaft, gear, etc.; weight, 1,200 pounds.

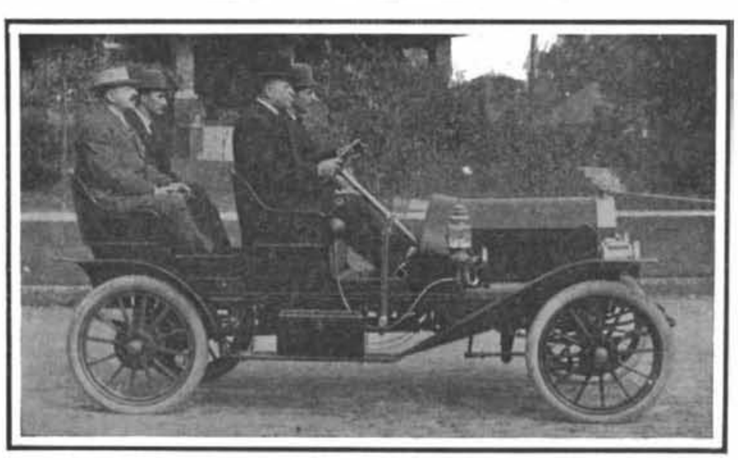
Ford 20 horse-power touring car.

4-cylinder; cellular radiator; low-tension magneto ignition; selective sliding gear transmission; shaft drive.

Locomobile 30 horse-power touring car.

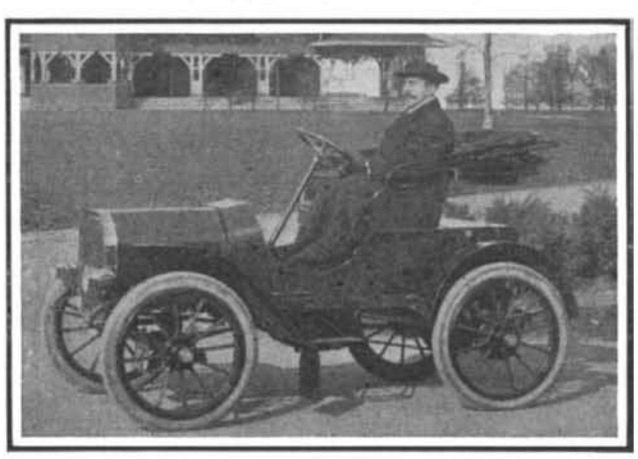
6-cylinder; jump spark ignition; three-disk cl
with four speeds forward and one re

Thomas 70-horse-p



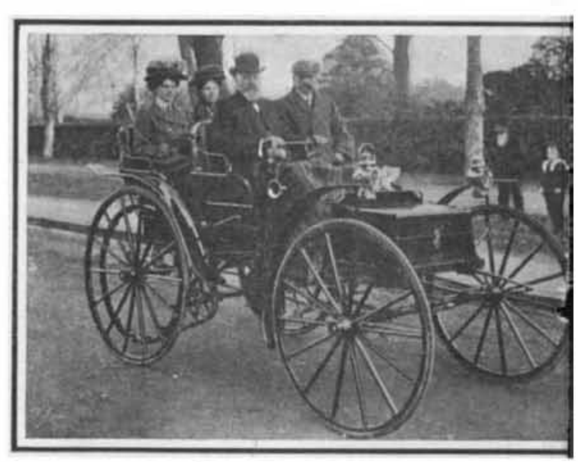
The transmission is of the double-disk type, the flywheel being used as one disk. The flywheel is horizontally placed to exert a gyroscopic effect in resisting shocks.

Blomstrom gyroscope car.



Six speeds forward, three reverse; motor, series wound, rated at 2 horse-power with 300 per cent overload capacity.

Baker electric runabout.



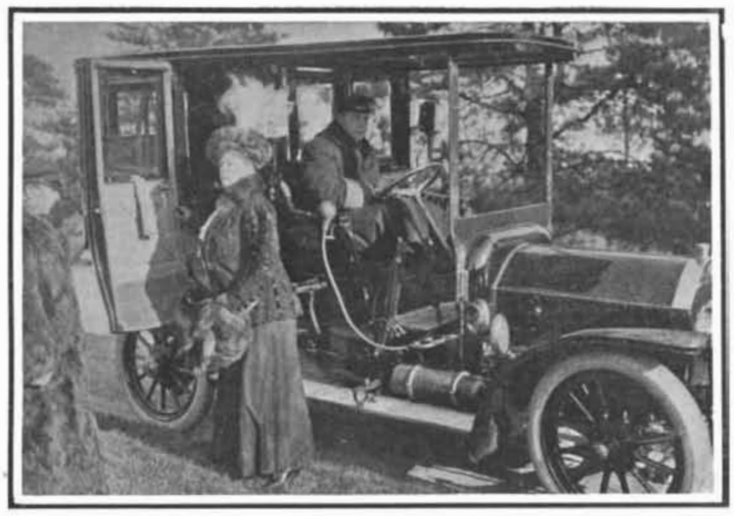
Direct power transmission by steel friction chain; ball and roller
for motor; 4 cylinders.

Holsman high-wheeled surrey.

THE CARS OF 1909

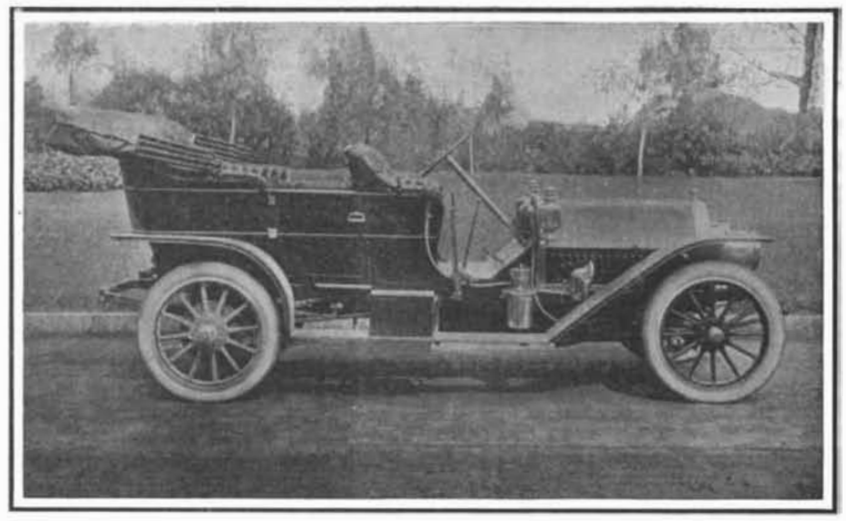
nder Rambler is a spare wheel, complete
d. The regular wheel is screwed to the
placed on the hub in three minutes.

g car.



Wheel base, 117 inches; 40 horse-power; 4 cylinders, 4¾ x 5¼ inches; cellular radiator; low-tension magneto; cone clutch; selective sliding gear transmission with four speeds forward and one reverse; shaft drive.

Studebaker limousine.

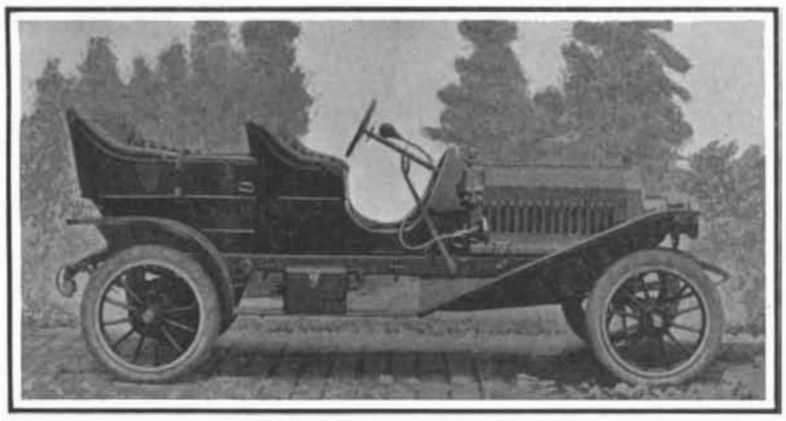


Wheel base, 120 inches; 40 to 45 horse-power; 4 cylinders 4¾ x 5 inches; double ignition system with Bosch magneto; cellular radiator; cone clutch; selective sliding gear with three speeds forward and one reverse; roller bearings throughout; shaft and bevel gear drive.

Speedwell touring car.

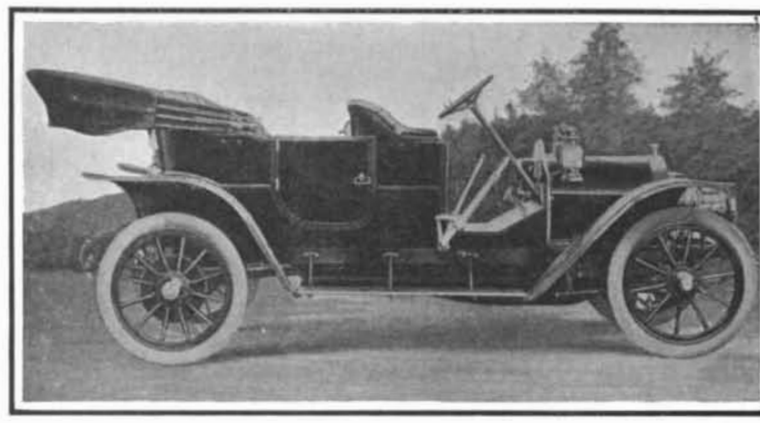
an hour. Ignition: Jump spark; four
. Irreversible bevel gear steering gear.
speeds forward and one reverse.

g car.



Wheel base, 110½ inches; 28 horse-power; 4 cylinders, 4 x 4 inches; water cooled; jump spark ignition (storage battery); splash lubrication; single silent chain drive inclosed in dust-tight metal case; friction change gear.

Lambert roadster.

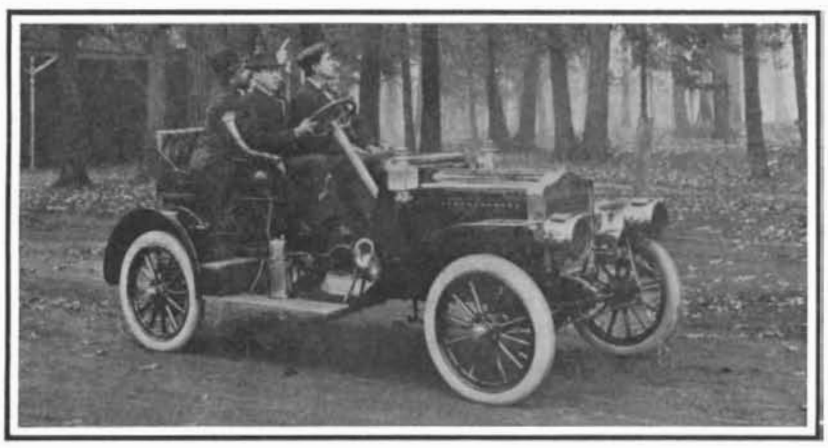


4 cylinders cast integrally; short bonnet; long wheel base; body swung between axles to giv ease in riding; ignition by storage battery and coil; special equipment for double ignition (magneto with separate set of spark plugs).

Chalmers-Detroit 30-horse-power touring car.

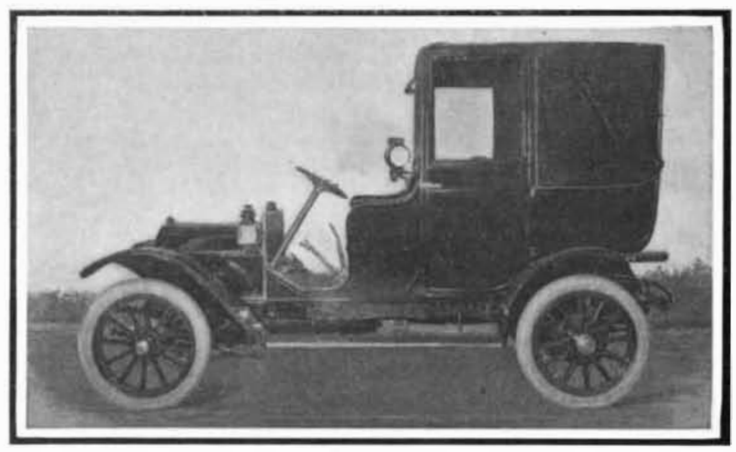
gnition; multiple-disk clutch; selective
rd and one reverse; shaft drive.

ower touring car.



4 cylinders; 24 horse-power; magneto and battery ignition; positive shaft-driven oiler; honeycomb cooler; sliding gear transmission, three speeds forward and one reverse; bevel gear drive.

Maxwell-Briscoe 30-horse-power.



Wheel base, 106 inches; wheel tread, 54 inches; wheels, 32 x 4 inches (all four); 4 cylinders 30 horse-power; seating capacity, 4; steering on left-hand side; turns in 25 feet.

Cleveland auto cab.

itch; selective sliding gear transmission
erse; double side chain drive.

wer flyabout.

Vertical 2-cycle motor, 3 cylinders; jump spark ignition (dry and storage battery); multiple-disk clutch; shaft drive; speed, 40 miles an hour.

Atlas 34-horse-power touring car.

Wheel base, 95 inches; 18-20 horse-power motor; thermo-syphon cooling; mechanical oiler; jump spark ignition; friction transmission; pressed steel frame.

Carter car gentlemen's roadster.

earings

20 horse-power; 2-cylinder water-cooled motor; friction drive; force feed oiler; long Concord side springs.

Shacht automobile buggy.

Wheel base, 95 inches; double opposed motor half offset; 16 horse-power; jump spark ignition (coil and battery).

McIntyre solid-tire high-wheel runabout.

2-cylinder, 14-horse-power engine; planetary transmission; two speed forward and one reverse; maximum speed, 30 miles.

Black automobile buggy.

--BIG AND LITTLE.