

The Model T Ignition Coil

Part I: The Ford/K-W Ignition Company Story

By Trent Boggess and Ronald Patterson

“All in all, the magneto commutator coil units supplied by the Ford Motor Company did a better and more creditable job than anything offered by the accessory firms.”

- Reminiscences of H.L. Maher

What could be more characteristic of a Model T Ford than a box containing four vibrator ignition coils on the dash? Coils that always sound like a nest full of angry bees. Coils that sometimes will reward the Model T driver with a “free start” if when the engine was turned off, one of the pistons stopped just after top-dead center on the compression stroke.

The vibrator ignition coil system did not originate with the Model T, nevertheless; the Model T was its most famous application. In this and the following two articles we will attempt to comprehensively present the story of the Model T ignition coil. Part 1 presents a brief history of the Model T ignition coil beginning with the evolution of the timer and vibrator coil ignition system in early Ford design automobiles. We will also go on to describe the various brands of ignition coils used on Model Ts during the first five years of production and some of the problems that developed with these coils.

In Part 2 we will present the story of how Ford came to standardize on the ignition coil designed by Joseph Williams of the K-W Ignition Company in 1913 and the subsequent business relationship between Ford and K-W Ignition. Finally, in Part 3, we will attempt to construct an anthology of the various types of post-1913 ignition coils used on the Model T, describing their features and roughly dating their use.

Two of the thorniest problems in the development of the internal combustion engine were the issues of carburetion and ignition. The first involved getting the right mixture of highly combustible fuel and air into the cylinders and the second involved igniting it at just the right moment. Henry Ford's first car, the 1896 Quadricycle, took a brut-force direct approach to solving both of these problems. Carburetion was achieved by the expedient of a needle valve that allowed gasoline to drip into the intake manifold at a more or less controlled rate. Once in the manifold, the gas would be swept up and drawn into the cylinders by the air rushing through the

manifold on the intake stroke. Once in the cylinders, the air-fuel mixture was compressed and made ready for ignition. Again Ford adopted a direct approach to solving this problem. The mixture was ignited by a technique known as “make and break.” This simple ignition system had been in use in stationary gas engines for a number of years and was later used on several early automobiles. Two electrodes, or contacts, were attached inside the cylinder head, one insulated and fixed, and the other one moveable and grounded. Electricity from a battery passed first through a simple electrical coil (that both created an electrical resistance and intensified the spark), then through the contacts to the ground and finally back to the battery to complete the circuit. When the two contacts were separated by some mechanical means (in Ford's case, a bolt attached to the top of the piston would strike the moveable contact just before the piston reached the top of its stroke), a spark occurred that ignited the fuel-air mixture within the cylinder.

This rough-but-ready solution to the ignition problem had one serious drawback. The timing of the ignition was fixed by the bolt on the piston at about 10 degrees before top dead center. The spark could not be retarded for starting the engine nor advanced to increase its speed. [In later development of the make-and-break system for stationary engines and early automobiles, the contacts were in the cylinder, but the mechanism for opening and closing the contacts were placed outside the cylinder. This allowed for a means for advancing and retarding the spark.] All in all, Henry Ford's primitive ignition system combined with its equally crude carburetor worked, but it severely restricted the performance and range of operation of the engine on his first car. A better system was needed. Fortunately for Henry Ford, he made the acquaintance of Edward S. Huff and was able to enlist him in Ford's automobile development work.

Amongst Henry Ford's many, early lieutenants, none was more talented in the field of electricity than Ed Huff. One early associate

recalled “Ed was quite a genius. He was a mechanical genius in putting things together. He had quite a yen for electricity and gears and things of that kind.” When it came to the problem of ignition “He was just the type of fellow who was needed on that job.”

In early 1902 while Ford was designing and building what would become the famous “999” race car, he delegated the task of designing of the ignition system to Ed Huff. Huff abandoned the make and break ignition system in favor of a “jump spark” system. The jump spark ignition system was not a new development, and in fact had been in use for nearly forty years. The Frenchman Lenoir, who is credited with building the first successful internal

combustion engine, used something like it in his engines as early as 1862.²

The jump spark system employed a spark plug, a commutator that timed the spark to the cylinder, a battery to serve as a source of current, and a vibrator coil. (See Photo 1). The theory of the vibrator coil was quite complex for the time. It consisted of two circuits of wires wound around an iron core. (See Photo 2). The primary circuit consisted of a number of turns of fairly heavy gauge wire. When current from the battery flowed through this circuit it served to turn the iron core into an electromagnet. The secondary circuit consisted of a very large number of turns of a very fine wire wrapped around the same iron core. This secondary circuit was connected to the spark plug. When the primary circuit was broken, the magnetic field around the iron core

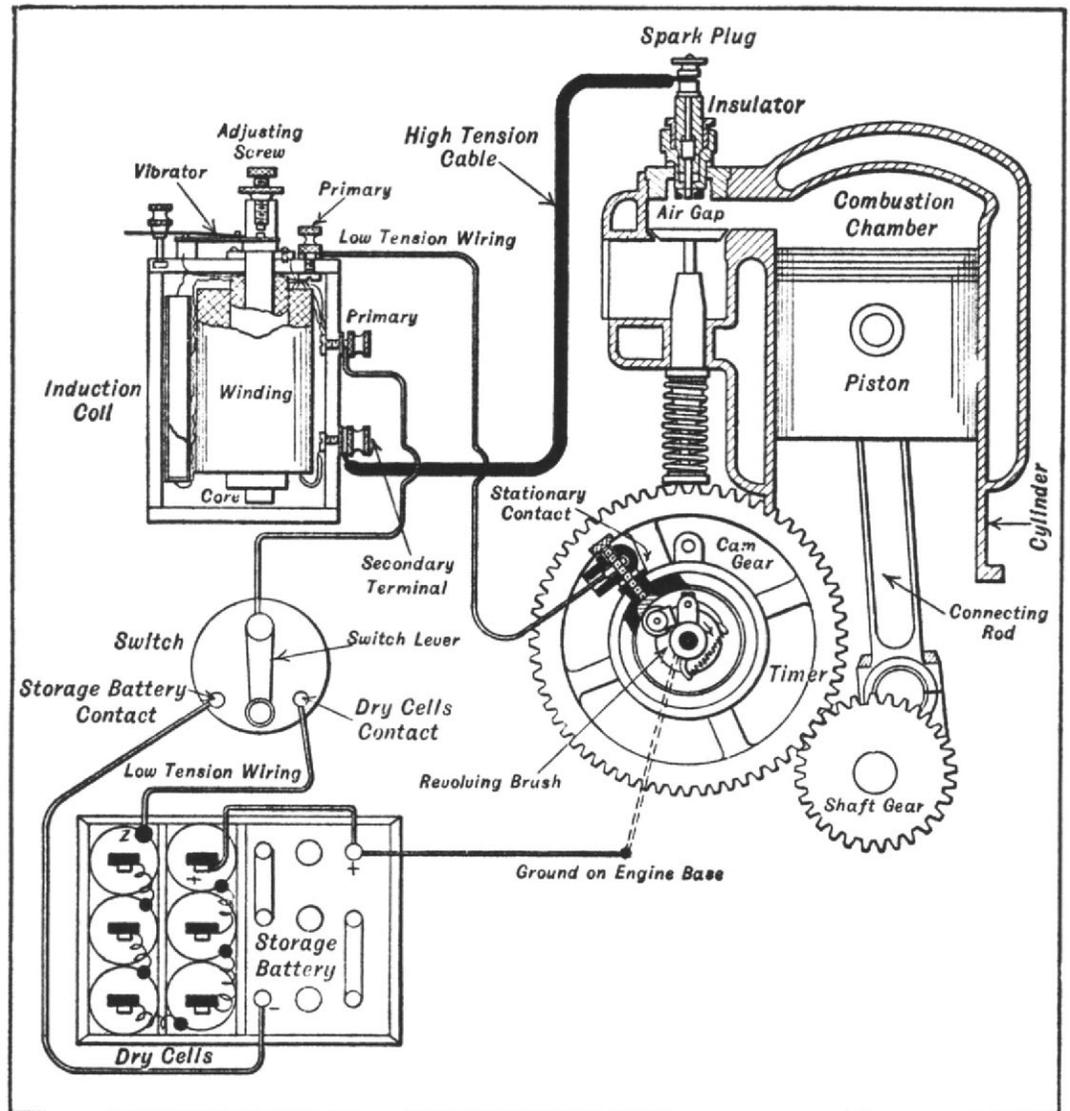


Photo 1: A simple vibrator coil ignition system showing the layout of the commutator, coil and wiring. Illustration from Victor Page The Model T Ford Car, 1917 Edition, Norman W. Henley Publishing Co, NY, 1917, p. 74.

collapsed, inducing an electrical current through the secondary circuit. Because of the large number of turns of wire in the secondary circuit, a very strong electrical voltage was induced in it. While brief, this high voltage was sufficient to jump across the gap between the electrodes of the spark plug and ignite the fuel-air mixture in the cylinder. The term vibrator coil arose from the use of two electrical contacts and a spring arrangement to close and open the circuit between the battery and the primary circuit. When the primary circuit was closed and the iron core was saturated with magnetism, the spring would be attracted towards the iron core, separating the contacts, and thus breaking the primary circuit. Once the contact was broken, the magnetic field collapsed, inducing a high voltage in the secondary circuit that would jump the gap at the spark

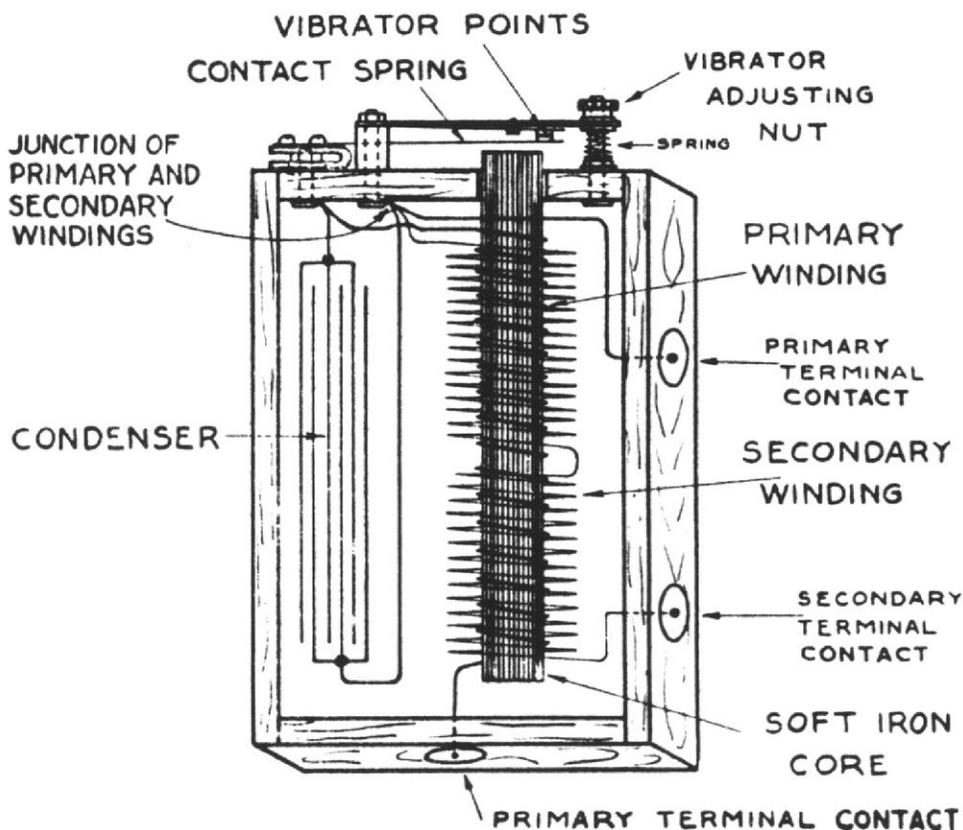


FIG. 184.—Ford (K-W) induction coil, showing typical three-terminal coil.

Photo 2: Schematic diagram of the K-W vibrator coil showing the primary and secondary circuits, the contact points and the condenser. Illustration from George W. Hobbs and Ben G. Elliott *The Gasoline Automobile*, 3rd Ed., McGraw-Hill Book Company, Inc, NY, 1924, p. 162.

plug. At the same time, the collapse of the magnetic field released the spring allowing the contacts to touch and reestablish the primary circuit and thereby start the entire process all over again. This continuous making and breaking of the contacts resulted in a vibration or buzzing of the coil and an accompanying stream of sparks.³

A vibrator coil and the “kick” coil used on the make and break ignition systems share a common component: a primary circuit wrapped around a soft iron core that becomes an electromagnet when current flows through it. In both cases when the circuit is broken, either by the separation of contacts in the make and break system or by the separation of the points of a vibrator coil, the magnetic field collapses through the windings of the primary circuit and induces a surge of voltage in that circuit as well. This surge of voltage can be 50 to 100 times greater than the voltage in the primary circuit before the circuit was broken. It is this surge that

produces the spark that enables the make and break ignition system to ignite the charge in the cylinder.

As in the case of the kick coil, a vibrator coil also tends to produce a spark between the contact points of the vibrator when the primary circuit is broken. This spark is undesirable for two reasons. First, it will cause the contacts between the vibrator to erode rapidly. Second, since current continues to flow through the primary circuit as the spark jumps between the point contact, the magnetic field in the iron core tends to collapse rather slowly. This in turn reduces the strength of the voltage induced in the secondary circuit.

In order to reduce the sparking between the contact points of the vibrator coil and

to quickly collapse the magnetic field, a condenser is used in the vibrator coil. A condenser is a device designed to absorb or store up a charge of electricity. At the beginning of the century, condensers were made of two sheets of tin foil separated from each other by sheets of paper coated in paraffin and rolled up to make the assembly a reasonable size. At the instant the contact points separate, the current flowing in the primary circuit begins to flow into one side of the condenser. This diverts the current and keeps it from jumping the gap between the points when they separate. As current flows into the condenser, the electrical potential on the one side of the condenser becomes much higher than the other side. This in turn causes a discharge back through the primary circuit in the opposite direction. The return flow of current out of the condenser very quickly dampens the current in the primary circuit, contributing to a rapid collapse of the magnetic field in the iron core and conse-

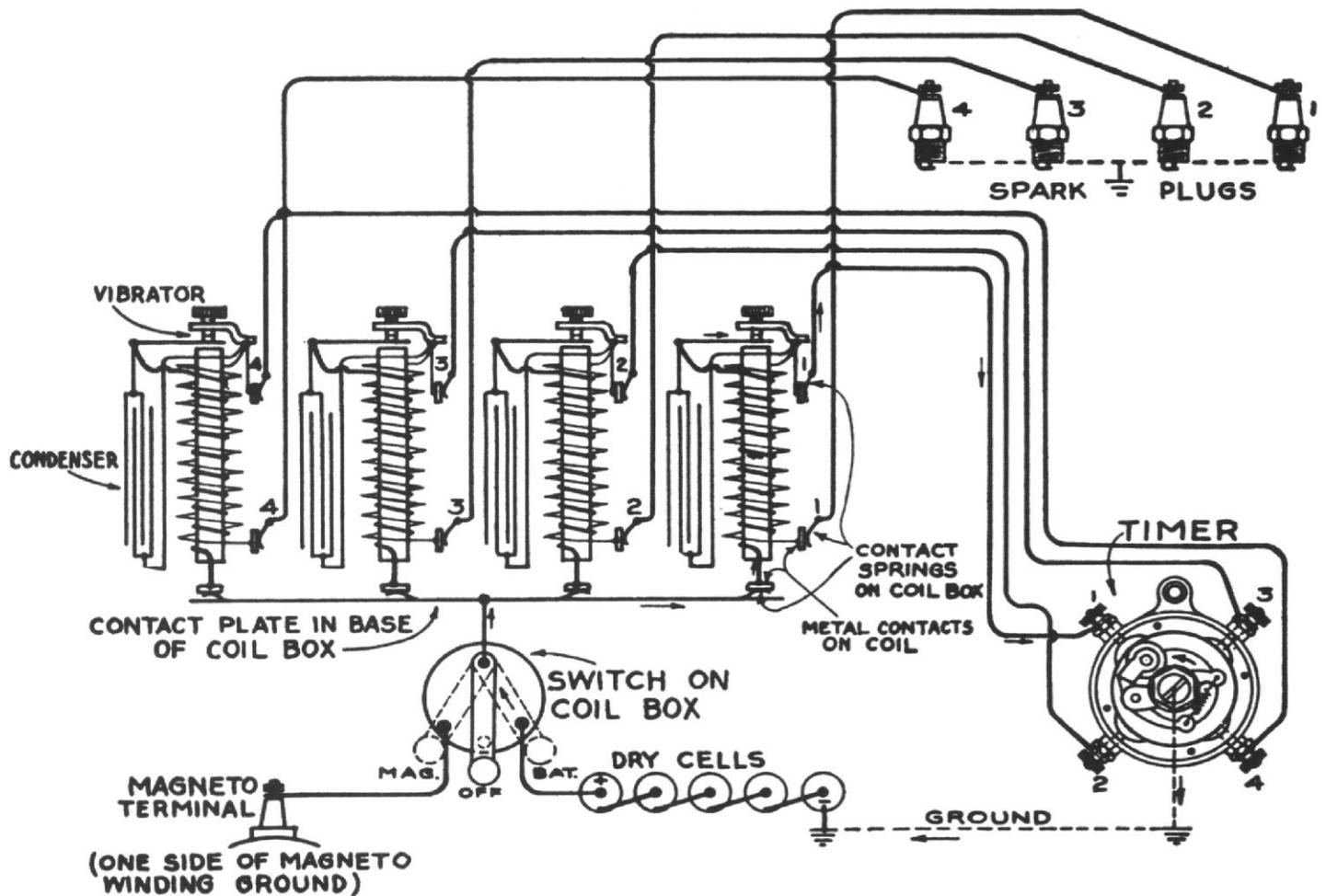


FIG. 186.—Diagram of four-cylinder vibrating-coil ignition system.

Photo 3: *Wiring diagram for a four-cylinder vibrator coil ignition system. Each cylinder requires a separate vibrator coil unit. Illustration from George W. Hobbs and Ben G. Elliott The Gasoline Automobile, 3rd Edition, McGraw-Hill Book Company, Inc, NY, 1924, p. 163.*

quently induces a much higher voltage in the secondary circuit.*

A vibrator coil will continue to produce a series of sparks so long as current is applied to the primary circuit. It is necessary to break the primary circuit in order to stop the sparks when they were not wanted. To accomplish this, a commutator or timer is used. The timer is operated by the engine and permits the closing and opening of the primary circuit from the battery or magneto to the coil. The closing of contact within the timer would allow current to flow through the primary circuit at the proper time, initiating the vibrating of the coil and the stream of sparks. The timer is adjustable so that the circuit could be connected earlier or later in relation to the position of the piston within the

cylinder, thus advancing or retarding the spark.

In multi-cylinder engines, the vibrator coil ignition system requires a separate spark plug, vibrator coil and circuit for each cylinder. (See Photo 3). The timer is usually driven by the engine's camshaft, which rotates once for every two revolutions of the crankshaft. The timer has a number of separate contacts, one for each cylinder. For the 999 race car, the biggest and most powerful engine that Ford had built up to that time, Ed Huff made a separate ignition coil for each cylinder. Each coil was placed in a wood box on the dash behind the engine with the vibrator extending out toward the back of the car. The primary circuit of each coil was wired in series to a bank of dry cell batteries and the timer. (See Photos 4 and 5) The success of the 999 race car

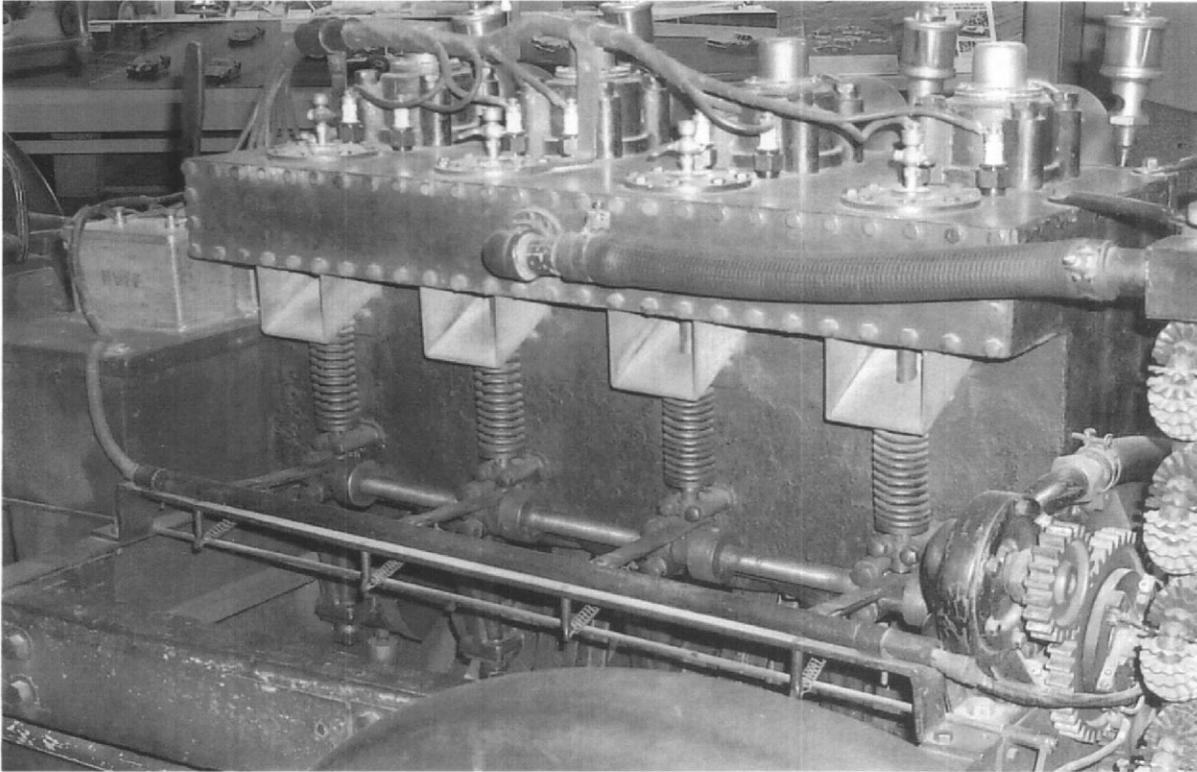
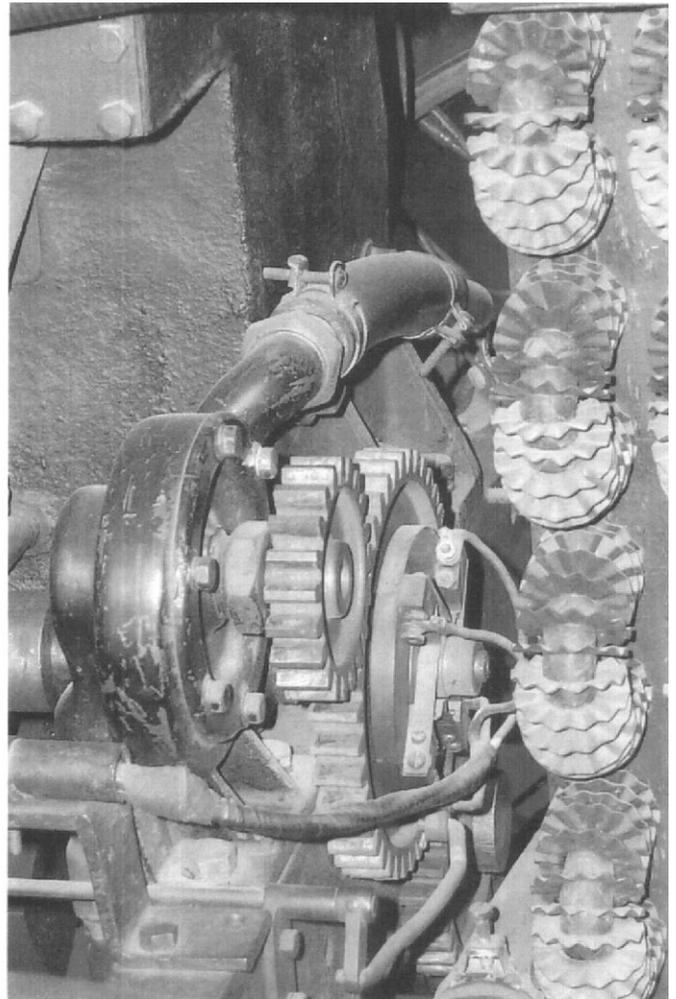


Photo 4 (above): The vibrator coil ignition system on Henry Ford's 1902 race car the "999." The timer is located at the front of the camshaft. The commutator wires are carried in a conduit along the right hand side of the engine to four separate vibrator coils mounted directly behind the engine. The high tension wires travel from the vibrator coils, across the top of the engine and split two the two separate sparkplugs used on each cylinder. These coils were made by Ed Huff and are so marked on the sides of each of them.

Photo 5 (right): A close up view of the timer on the "999" race car showing the four contacts, one for each cylinder. The small gear visible in the photograph drives the water circulating pump.



in late 1902 was due to its power and speed, which in part was attributable to the jump spark ignition system Huff had installed. When the Ford Motor Company was formed the following year and the Company's first products sent to market, they too employed the same type of jump spark ignition system that had proven so successful on the 999.

The 1903 Model A Fords used two-cylinder engines equipped with jump spark ignition systems patterned after the one used on the 999. While Ed Huff continued to assist in the research and design of the company's evolving products,

Ford turned to other companies to supply it with the ignition components for its cars. One of the first principle suppliers of spark plugs and vibrator coils was the Splitdorf Company of New York. Splitdorf was one of the best known of the early ignition system manufacturers. Its products, which included spark plugs and commutators as well as ignition coils, were used on many different brands of early automobiles as well as Ford. For the first three and a half years of the Ford Motor Company, Splitdorf coils were used almost exclusively on the Company's products. In addition to the Model A, they were used on the Models B, C, F and the famous Model N Ford of 1906.

During 1907 Ford made two important decisions that affect the ignition coil story. First, Ford decided to begin buying vibrator coils from a second firm and installing them on the Company's two newest Models, the R and the S. The new coil supplier was the Heinze Electrical Company of Lowell, Massachusetts. The exact reason for taking on this new vendor is not known, but according to Ford's financial records, after March 1907 Heinze began taking a larger and larger portion of the Company's coil business, and purchases from Splitdorf dwindled over the next 18 months.⁵

A second and more significant decision was

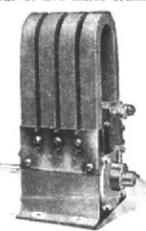


Simplicity is the Strong Point of the K-W Magneto

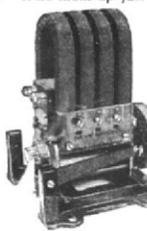
IT is the simplest piece of mechanism that could possibly be conceived. In place of the moving wires, brushes, traps and triggers of the average Magneto, the K-W Magneto has only one moving part which runs in the highest grade of ball bearings. The magnetism of the K-W Magneto will last forever.

☛ You don't need batteries of any kind when you have a K-W Magneto as we guarantee that **the K-W Magneto will start any engine without batteries** and run it perfectly at all speeds from the lowest to the very highest, provided a K-W Coil is used with it or a K-W Master Vibrator is used with the old coil.

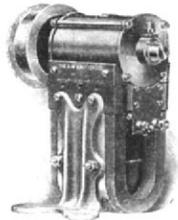
☛ The difference in models A, B and F Magnetos is merely for convenience in attaching to the engine as the work they will do is the same. This also applies to model A-L, B-L and F-L. They can be mounted in any position and run in either direction. The speed is four or five times crank shaft speed. Wire them up just like a set of batteries.



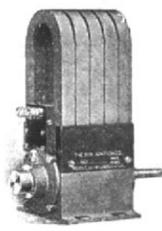
Model A, for Ignition only, \$35.
Model A-L, for combined Ignition and Lighting or Lighting only, \$50.
Belt drive or gear drive. Jump spark. Very simple and efficient. Makes you throw your batteries away.



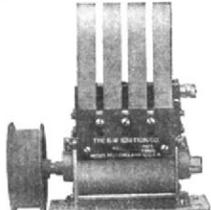
Model B, for Ignition only, \$35.00
Model B-L, for combined Ignition and Lighting or Lighting only, \$50.00
Friction drive and will not slip. A standard for good ignition and can not be beaten.



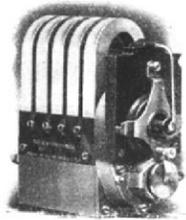
Model F, for Ignition only, \$35.
Model F-L, for combined Ignition and Lighting or Lighting only, \$50
Belt drive. Has bracket for attaching to frame of car. Good on any automobile.



Model C, for Ignition only, \$45.
Model C-L, for combined Ignition and Lighting, or Lighting only, \$60.
Just like model A, except has one extra magnet and is much stronger and intended for the heaviest engines.

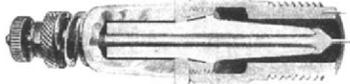


"THE MOTOR BOAT SPECIAL"
Model M, for Ignition only, \$35.00
Model M-L, for combined Ignition and Lighting or Lighting only, \$50.00
Runs in either direction and two cycle engines can be reversed on it. Makes you throw your batteries overboard.



HIGH TENSION
Gear driven at engine speed. A complete ignition system, nothing else needed but the spark plugs. Absolutely no coil of any kind used. The most perfect ignition system in the world. Guaranteed to start any engine easily on the first quarter turn of the crank and save 25% of the gasoline.
Will not run lights.

For Make-and-Break Spark
Model A-M for engines under 30 h. p. \$35.00
Model C-M for engines over 30 h. p. \$45.00
Just like models A and C, except has a different winding for Make-and-Break. Must be Gear driven. No coil is needed. Engine can easily be started on it. The best Magneto for Make-and-Break spark. Does not furnish lights.



The K-W Spark Plug, \$1.00 postpaid
Six for \$5.00
No packing is used, but accurate joints positively prevent leaking of compression. A spring at the end takes up the heat expansion and effectually prevents cracked porcelains. Soot proof and will not short circuit. The more plugs of other makes you have tried, the better you will like this one. If your dealer does not handle it, send direct to us. Take no substitute.

Model H 4 Magnets	Model HT- 5 Magnets
2, 3 and 4 cylinder \$ 75.00	\$100.00
6 cylinder 85.00	110.00
Say whether for two or four cycle.	
Model O, for 2-cylinder opposed.	
Has no distributor \$50.00.	

Photo 6: Illustration of magnetos supplied by the K-W Ignition Company from their 1910 catalog. The Model F seems to have been intended for the Models N, R and S Ford.

From the collections of Henry Ford Museum & Greenfield Village

made when Henry Ford concluded that his lower priced cars needed to be able to produce their own electricity for ignition instead of relying exclusively on batteries for current. Most of Ford's early models had relied on batteries to

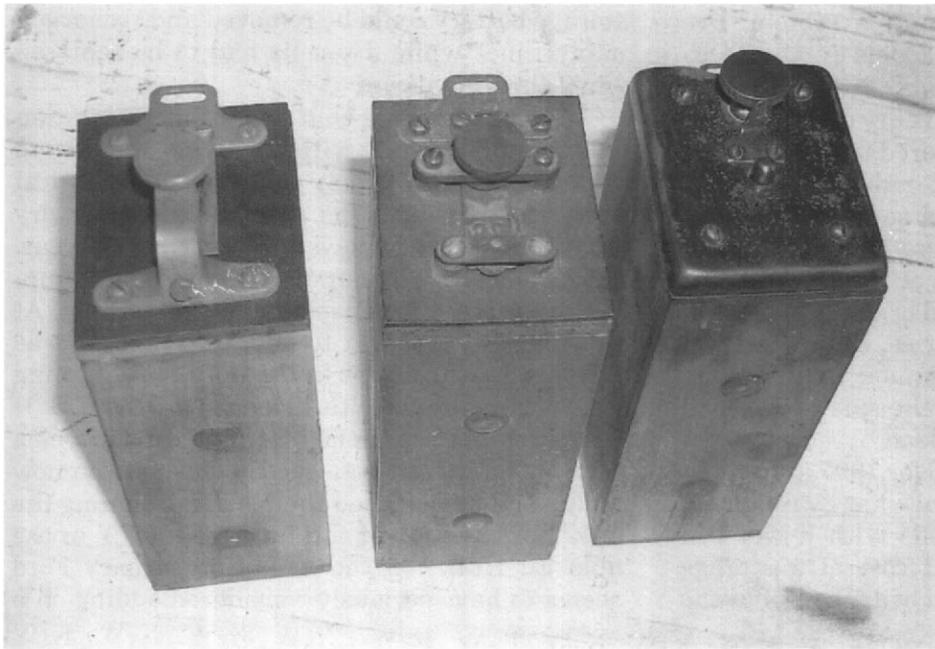
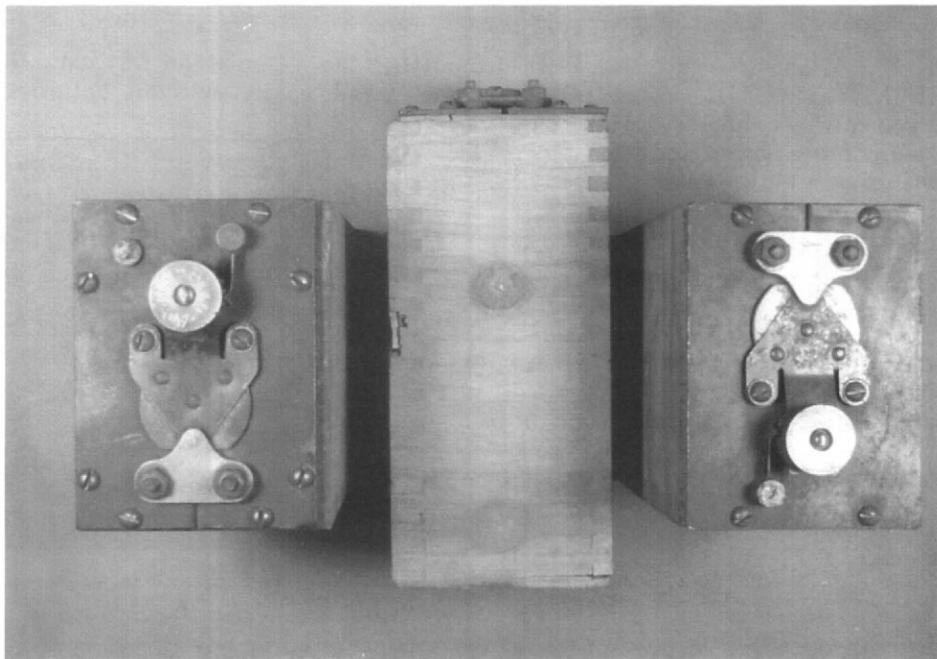


Photo 8: Kingston Coil used on the Model T from 1909-1912. From left to right, the 1909-10 Kingston Coil, the 1911 coil and a Kingston coil used for a short time in 1912. This last coil is easily identifiable by its metal top covering the points.

Photo 9: Heinze coils used on the Model From 1909 to 1913. The coils whose tops are held to the box by eight brass headed screws appear to have been used from 1909 to 1911. It is believed that in 1912 the number of screws holding the top to the box decreased from eight to four.



dynamo to the Models N, R, and S cars. This dynamo was to be located on the left-hand side of the engine and was to be powered by a belt from the engine flywheel to the dynamo. To supply this dynamo Ford turned to a little known

electrical company in Cleveland, Ohio: the K-W Ignition Company.

Relatively little is known about the early years of the K-W Ignition Company. The Cleveland City Directory for 1908 lists the K-W Ignition Company's address as being the Whitney Building. Its officers were Joseph A. Williams, president; William Kaple, vice-president; and, A. F. Williams, secretary. It is almost certain that the company's name was derived from the names of these two principle officers: Kaple and Williams.⁸

A 1910 K-W Ignition Company catalog describes the company's product line. It included electric headlights, spark coils and magnetos. It was the company's Model F magneto that appears to have attracted the attention of Henry Ford. (See Photo 6). This magneto was really an alternator or dynamo that was driven by a belt from the automobile engine's flywheel. The power generated by the magneto was then used to supply the stock ignition coils of the car. K-W advertised that this magneto was so powerful that it was actually guaranteed to start any engine without the use of batteries.⁹

Evidence that Ford gave serious consideration to adopting the K-W magneto can be found on original Model N factory drawings. A complete set of drawings was made by Ford draftsmen during late 1907 for all of the parts necessary to attach the K-W magneto to the engine of the Models N, R and S Fords."

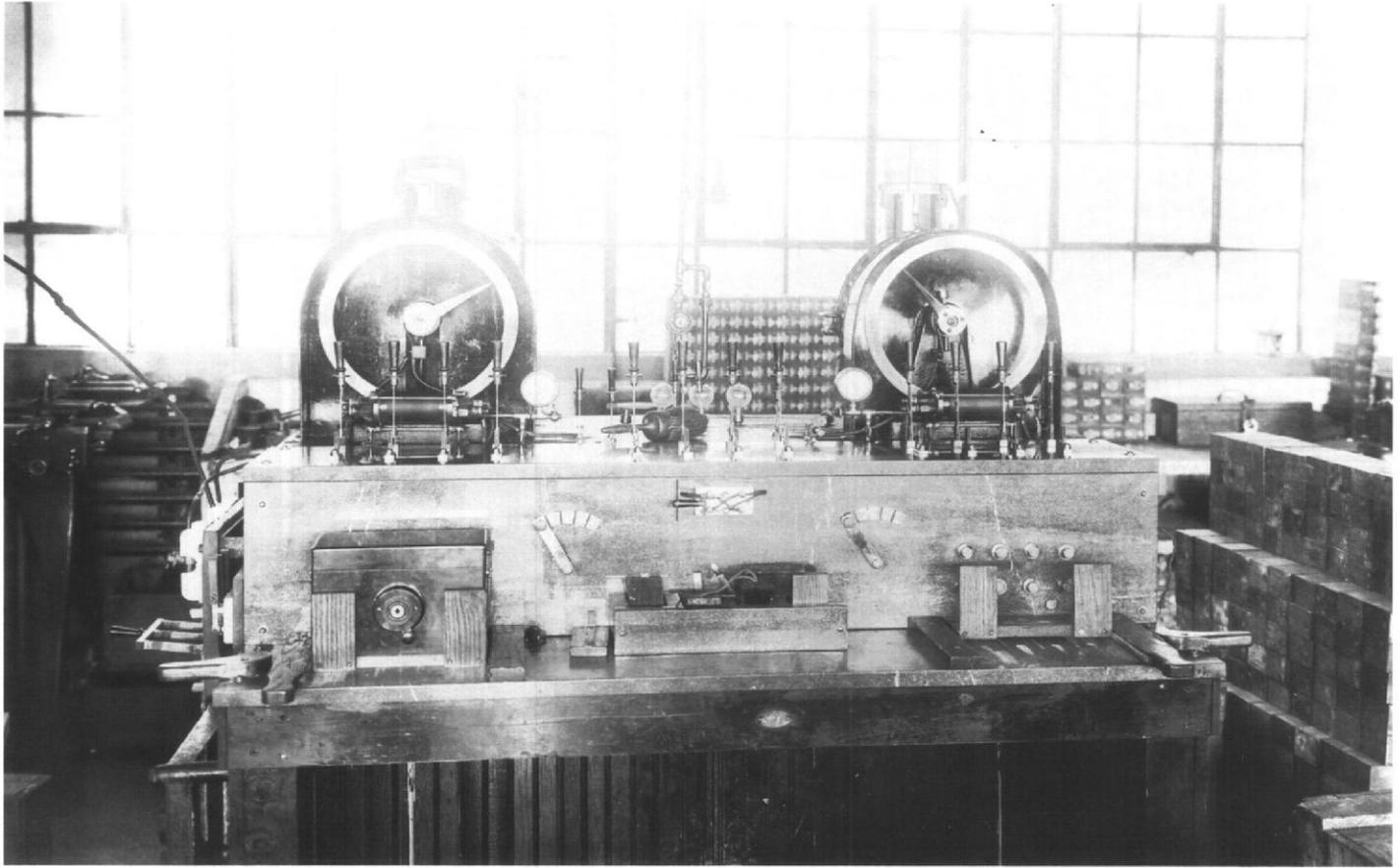


Photo 10: *Adjusting Model T Coils at the Highland Park plant ca. 1911. A Heinze coil unit is in the test bed on the left. The large stack of coils on the right hand side appear to be individual Heinze coil units. Stacked against the window in the background are appear to be Kingston coil units.*

From the Collections of the Henry Ford Museum & Greenfield Village. Neg no. P.O-8502.

Although a complete set of drawings for attaching the K-W magneto were made, it does not appear that Ford ever offered the K-W magneto either as standard equipment or a factory authorized accessory on the Models N, R, and S Fords. Perhaps Henry Ford concluded that Huffs progress on the flywheel magneto for the Model T would soon make the N, R and S models obsolete along with ancillary magnetos. In any case, this first business relationship with the K-W Ignition Company quickly ended. However, the following year, 1908, K-W placed advertisements in *Horseless Age* and other early automobile trade journals displaying the specially designed unit and offering it for sale. (See Photo 7).

On October 1, 1908 the Model T Ford was introduced. It used an ignition system patterned after that used in the earlier Models N, R and S. While the locations of some of the components were changed as well as the method of wiring, it remained an ignition system based on vibrator coils and a commutator. The major innovation

was the use of the flywheel magneto. This virtually maintenance-free electric dynamo provided sufficient alternating current to operate the coils. On well-tuned Model Ts, the car would start on the magneto and the use of a battery could be dispensed with altogether.

Along with the new model came a new ignition coil supplier. The new vendor was the Kokomo Electric Company of Kokomo, Indiana who supplied ignition coils under the trade name Kingston." A bit later in 1909 Heinze resumed coil sales to Ford and a substantial portion of the late 1909 production came so equipped.¹² (See Photos 8 and 9).

While the flywheel magneto seems to have solved the problem of a source of current for the ignition coils, there is also some evidence that it created new problems. Letters and other documents in the collections of the Research Center indicate that during 1910 Ford began looking at other coil maker's products and consulting with outside engineers on the coil issue. This may have led to Ford taking on a third supplier of

coils, the Jacobson and Brandow firm of Pittsfield, Massachusetts. (See Photo 11).

As nearly as can be determined at this time the problem involved the synchronization of the four coil units. Synchronization refers to the timing of the high-tension spark from each of the coils. Ideally, each coil will send a high voltage jolt to its respective sparkplug at the same relative point of crankshaft rotation and piston travel. Ignition of each cylinder at the same relative point will tend to promote a smooth running engine. However, synchronizing four different vibrator coil units so that each will send its spark at the proper moment is a bit problematic.

The reason for this arises from the theory of the vibrator coil. Recall that current flowing through the primary windings of the coil turns the iron core into an electromagnet. The magnetic field from this core in turn attracts a steel spring which is making contact to complete the primary circuit. When the contact brakes, current stops flowing through the primary circuit, the magnetic field collapses, inducing a high voltage through the secondary circuit connected



Photo 11: *Jacobson and Brandow coils used in 1910, 1911 and 1912.
The taller of the two coils was used in 1910 and 1911.
The shorter coil saw limited use in 1912.*

to the spark plug. The nature of this design makes the breaking of the contact and the induction of the high voltage in the secondary circuit sensitive to the voltage applied to the primary circuit. Moreover, variations in the tension of the contact spring and its distance from the iron core of the magnet can greatly effect the amount of current that is required to attract the spring, break the contact, and induce the spark.

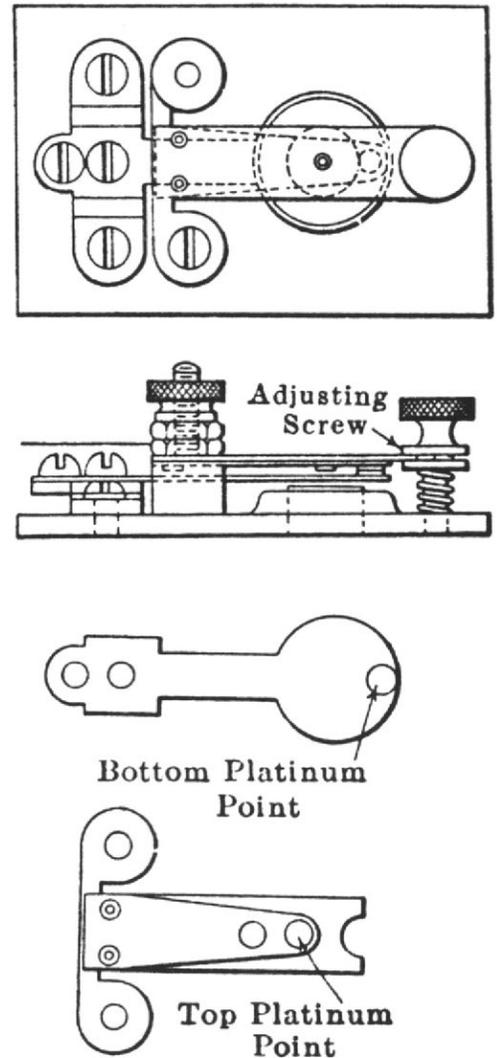
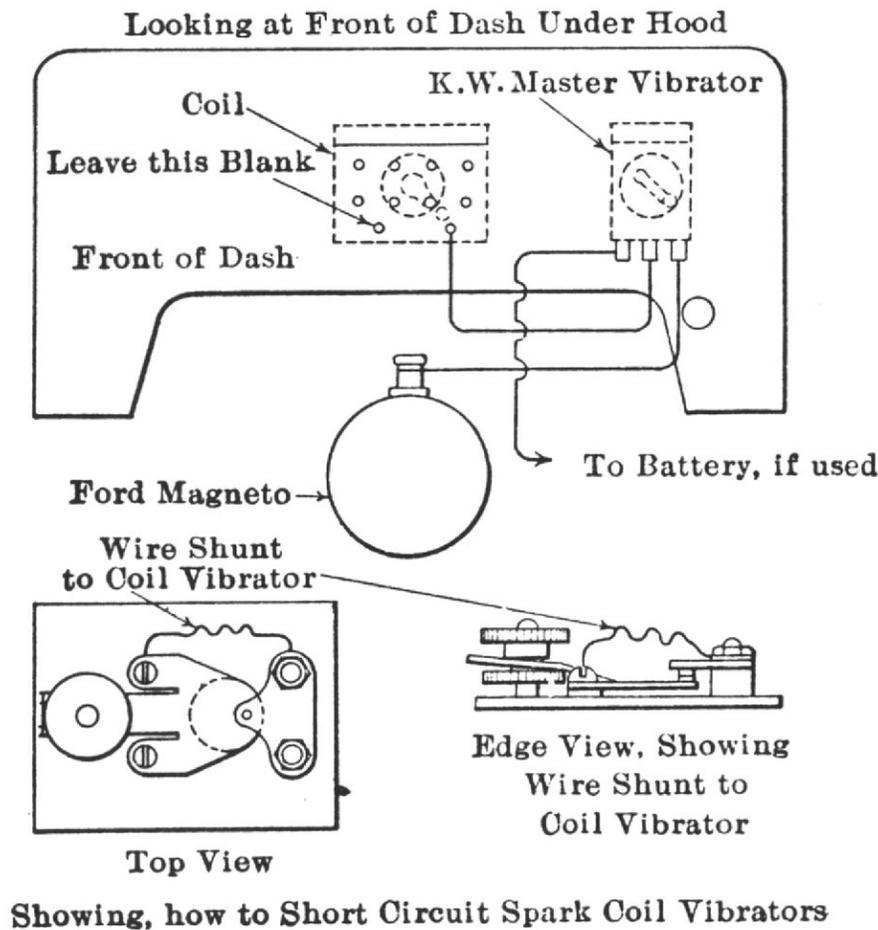


Photo 12: *Wiring diagram for a K-W Master Vibrator Coil. The points on the regular ignition coils were shorted out and the points on the master vibrator operated the four individual coil units. Illustration from Victor Page The Model T Ford Car, 1917 Edition, Norman W. Henley Publishing Co., Brooklyn, NY, P. 85.*

In a battery powered ignition system the voltage supplied to the primary circuit of the ignition coil is constant. Since each coil receives the same amount of voltage when the commutator makes contact, each coil will in turn send a high voltage surge to the spark plug almost instantly afterward. As long as the contacts in the commutator are properly arranged, synchronization will not be a great problem.. However, the Model T flywheel magneto produces an alternating current ranging from six to twenty-eight volts. This current occurs in the pattern of a sine wave that repeats itself 8 times over the course of one revolution of the crankshaft. Starting with the magnets on the flywheel located midway between two coils on the magneto coil ring, the voltage will be zero. As the magnets approach and pass over the center of the magneto coil, the

voltage will rise and reach a peak. As the magnets pass the center of the coils and rotate towards the midpoint between them again, the voltage will fall back towards zero. As the magnets continue their rotation the cycle will repeat itself, although with the current flowing in the opposite direction.

The performance of vibrator coils tends to vary somewhat from coil to coil. This performance is affected by the tension in the contact spring and its distance from the iron electromagnet core of the coil. When the tension of the vibrators and their distance from the core differ, then one vibrator coil may require a different threshold voltage level to produce a spark than another. That is, four volts may be sufficient for one coil to begin to produce its stream of high voltage sparks while a second may require five

Photo 13 (opposite top): *Front view of a 1912 Kingston coil assembly incorporating a master vibrator coil in its design. The master vibrator is the middle unit in the coil. The other four are slaves. This box used the standard Kingston switch and latches for the top.*

Photo 14 (opposite bottom): *Rear view of the special 1912 Kingston coil assembly. Note the clever way Kingston modified the back of this box so that it would fit the standard Ford dash. The commutator and high tension terminals for the second and third coils and the magneto and battery terminals are attached to brass contacts that shift the terminal posts in toward the center of the box.*

and a halfvolts before it begins to emit its stream of sparks. Since the voltage level produced by the flywheel magneto varies with the rotation of the crankshaft, this means that different vibrator coils would send a spark at a different relative point in crankshaft rotation and travel of the piston in the cylinder. For example, the first coil might send a spark at fifteen degrees of crankshaft rotation before the piston reached top dead center, the second might do so at thirteen degrees, the third at seventeen degrees, and the fourth at sixteen degrees. Since each cylinder will be firing at a slightly different point, the power produced in each cylinder will also be different. This tends to result in a rather rough-running engine.

One solution to the coil synchronization problem was the use of a "master vibrator" coil.

This is a specially built coil unit that is used in conjunction with the regular factory issued coils on the car. The principle behind the master vibrator coil is quite simple. The regular vibrator points on the factory issued coils were disabled and the master vibrator coil was wired into the circuit so that the points and primary circuit on the master would operate the primary circuits on each of the factory issued coils. With only the one set of points on the primary circuit of the master coil operating, it insured that coils for each separate cylinder would send a spark to the plug at the same relative point of crankshaft rotation and piston travel. With each cylinder receiving its ignition spark at the same point, power was equalized between the cylinders and a much smoother running engine was achieved. Master vibrator coils were manufactured and sold by many early automotive ignition companies including Jacobson and Brandow and K-W Ignition. (See Photo 12).

Ford resisted the master vibrator coil solution. Instead, Kingston and Heinze continued to make improvements in the designs of their coils to alleviate the problem. As stated above, the Jacobson and Brandow coils were adopted as standard equipment on many Model Ts because it was thought that the design of their points tended to reduce the synchronization problem. The problem persisted for several years, and during 1912 Ford even tried a modified Kingston design that included a master vibrator coil and four slaves all in the same box mounted on the dash. However, this Kingston design soon proved not to resolve the problem to Ford's satisfaction and all outstanding Kingston coils of this design were recalled and replaced by the factory.¹³ (See Photos 13 and 14) □

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Footnotes

¹ Reminiscences of William W. Pring, Accession 65, Research Center, Henry Ford Museum and Greenfield Village. p. 8. (Hereafter cited as Research Center).

² Charles E. Duryea, *Automobiles: Instruction Paper*, American School of Correspondence, Chicago, 1906, p. 68.

³ *Ibid.*, p. 70.

⁴ Frank D. Graham, *Audels New Automobile Guide for Mechanics, Operators and Servicemen*, Theo. Audel & Co., New York, 1943, pp.1902-1904.

⁵ Ford Motor Company Accounts Payable Ledger, Accession 623, Research Center.

⁶ Reminiscences of James Purdie, Accession 65, Research Center, pp. 66-67.

⁷ In their Reminiscences, both H.L. Maher and James Purdie give full credit for the idea of the flywheel magneto to Henry Ford, Accession 65, Research Center. See also "Henry Ford, Ed Huff and the Flywheel Magento", *The Vintage Ford*, Vol. 31, #2 (March-April 1996), pp. 20-33.

⁸ *The Cleveland Directory for the Year Ending 1908*, Cleveland Directory Company, Cleveland, Ohio, 1907, p. 786.

⁹ K-W, The K-W Ignition Company, Cleveland, Ohio, 1910. An original copy of this catalog can be found in the Trade Catalog collection at the Research Center.

¹⁰ Drawings for N-543, Acc. 1701, Research Center.

¹¹ Advertisement for K-W Ignition Co.'s Magneto, *Horseless Age*, Vol. 22, # 13, (September 23, 1908), p. 38.

¹² Documentation for the use of these coils can be found in the shipping invoices for the Model T 1909-1911, Accession 641, Boxes 1 and 2, Research Center.

¹³ Factory Letter for November 6, 1912, Accession 509, Research Center.

