AN ENGINEERING HISTORY OF THE SMALL MOTOR

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. the appearance of the device. This "Fort Wayne Vacuum Cleaner Motor," and the demands for this motor for vacuum cleaners and similar applications runs into enormous quantities. It is interesting to note that at the time of designing the original motor of this type the essential parts were copied after and reduced in size from existing motors of large sizes such as were in common use at that time. This design then demonstrated the practicability of the small motor and marked the real beginning of the growth of the small motor department of the General Electric Company.

The advancement in the arts and uses of electricity, brought about the desirability of alternating current for use in electric lighting and it has been the history of the small motor that it has followed the lead of electric lighting development. The use of alternatnig current for lighting made necessary the development of the alternating current small motor.

One of the first forms of alternating current small motor was that known as the split phase motor. This motor consisted of a stator or stationary element and a rotor or rotating element. The stator consisted of a ring of sheet steel iaminations in which were cut a number of incisions or slots. In parts of these were wound carefully insulated stator coils. In the remaining slots of this member were wound coils of bare copper wire, the ends of which were joned together to form a completely short circuited coil. The insulated coils were known as the main windings. The short circuited coils were called "shading coils" and they were used to sustain the magnetic action of the main coils, thereby creating the effect of an auxiliary winding placed midway between the main coils. This form of motor was used largely for electric fans of the ceiling type and this same general scheme of winding has continued in use for this purpose up to the present time.

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The "shading coil" type of winding was somewhat improved by the use of the so called "Tesla Split Phase Winding." This winding has a main winding of coarse wire in slots as explained above and an additional winding of fine wire placed midway between the coils of the coarse winding, but in the same slots. This accomplishes the same purpose as the "shading coil" winding mentioned above, but is much more effective since the action of producing an intervening field between the main coils is enforced instead of induced.

The rotor or rotating element of both the "shading coil" type of the **Tesla Split Phase** was of the "Squirrel Cage" variety. A "Squirrel cage rotor" or secondary element consists of a laminated sheet steel core through which extends copper rivets or bars, located near the air gap or air space between the stationary and rotating elements. These copper rivets or bars form intimate electrical connections between the copper sheets or end rings on the ends of the secondary element.

The electrical action obtained from a motor of this type may be summarized as follows:

The voltage is impressed upon the windings of the main coils and starting or "Split phase" coils alike. An electric current flows in these coils which magnetize the laminated structure of both the stator and rotor elements. The resulting magnetism induces currents in the secondary in certain phase relations such that these currents reacting with the magnetism, produce a rotational effort or torque. As the motor speeds up the rotating element generates a magnetizing force in the position of the auxiliary, or "Split Phase" winding and the utility and necessity of the latter disappears. Since the nature of this auxiliary winding is such that it would become very hot if left connected in the circuit, an automatic cut out device was designed to accomplish this, at a certain predetermined speed, and the motor operated thereafter on the main winding alone.

This type of motor known as the split phase induction motor, was originally made for use in small desk fans, but as designers and manufacturers advanced in the art it was found that by using a clutch it could be used for starting and operating machines requirin considerable power, i. e., these motors could be built in sizes ⅛ to ¼ H. P. These motors are of the constant speed type and lend themselves admirably to a great number of applications. While this type of motor was invented almost twenty years ago it is still in use and

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is now being manufactured by certain manufacturers. Improvements in design have enabled its manufacture omitting the clutch, which has been the source of more or less trouble.

The Fort Wayne Works of the General Electric Company builds this type of motor under the designation of type S. A., meaning "Small Alternating," and the ¼ H. P. size used for driving washing machines and similar devices will be made at Decatur. It consists of essential parts mentioned above, but in order to simplify and cheapen its cost without depreciating its reliability or worth in any respect, the "squirrel cage" secondary has been made the stationary member and the wire wound element has been made the rotor, in other words, the motor has been "turned inside out."

The motor as it is to be manufactured at Decatur will consist of the essential parts: The stator or squirrel cage, whose outside acts as a case or housing for the motor, the end shields or bearing arms, carrying the bearings, which center or locate the rotor or wound element which involves inside of the stator, and the rotor which carries a shaft collector ring and pulley. Running in contact with the collector ring, which carries the automatic cut-out, are the brushes The brushes are insulated by what is known as brushholders which terminate on the outside in what is known as terminals. It is at these terminals that the leads are connected from the power circuit.

Thus we see the several stages of development through which the small motor has passed—from that of very primitive and crude instrument of uncertain performance to a neat, compact device of powerful capabilities of doing work.

The reader should not lose sight of the fact that there are a number of other types of motors which have gone through similar evolutions to that of the split phase motor. The General Electric Company manufactures five other types of fractional horsepower motors—the repulsion induction type R. S. A. largely used for operating pumps, air compressors, etc.,—the polyphase induction motor type R. K. T., the straight series motor type S. D. A., largely used for vacuum cleaners, the universal motor used principally for electrically driven hand tools such as electric drills, valve grinders, and like devices, and the direct current motor type S. D. which is applicable to all services where direct current power is supplied. A great deal of time and labor has been spent on perfecting and improving these various types of motors

The art of small motor engineering has advanced from the old so called "cut and dry" method of designing to an exact science and the laws of motor design are as applicable to the ¼ H. P. motor as to the 1000 H. P. motor and there are numerous complexities entering into the design of fractional horsepower motors that can be neglected when working with motors of large capacity. No smal portion of the engineering work required in connection with the small motor is that of designing a motor suitable for a given application. As an example of this consided the phonograph motor. One of the first types of phonograph motors was designed to wind the phonograph springs, merely replacing the manual operation. This required a motor of special frame construction in order to permit its being mounted on the cabinet of a phonoraph in such a position as to replace the crank. A considerable speed reduction was necessary to provide the necessary turning effort at the slow speed at which the spring should be wound. At the same time it was necessary for the designer to bear in mind that the operation of the device must be as noiseless as possible. These considerations led to the use of a worm and wheel gear reduction, the "gear box" or housing for which was almost as large as the motor itself. Again the appearance of the motor and its mounting must be given attention, in order to make it attractive and saleable. The designer is further limited by the cost of the motor itself or making an adaptation of it to the machine to be driven. The demand for the "most for the least" must ever be considered in the manufacture and sale of small motors.

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