

Magneto (power generation)

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A **magneto** is an electrical generator that uses permanent magnets to produce alternating current. Unlike a dynamo, there is no commutator and so they cannot produce direct current. They are categorised as a form of alternator, although they are usually regarded as distinct from most other alternators, which use field coils rather than permanent magnets.

Magnetos date from the earliest days of electrical engineering. Despite this, they have never been widely applied for the purposes of bulk electricity generation, for the same purposes or to the same extent as either dynamos or alternators. Only in a few specialised cases, as described here, have they been used for power generation.



2kW *Société de l'Alliance* magneto generator for arc lamps, of around 1870

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Common uses of magnetos

Magnetos have advantages of simplicity and reliability, but are inefficient owing to the weak magnetic flux available from their permanent magnets. This restricted their use for high-power applications.

Some did find use as telephone magnetos in early telephones, particularly for ringing.

The most common application for magnetos was as an ignition magneto, in spark-ignition petrol engines, ranging from early cars to aircraft (for reliability) and small engines such as chainsaws (for simplicity).

Magnetos for power generation

Early power generation systems adopted bipolar dynamos as their generators. These had a two-pole stator with a field winding. It could generate considerable flux, and thus power, for the time. They also required a commutator to produce a direct current (DC) output, which was complex to make and required regular maintenance. In contrast magnetos were not generally used, as they were inadequately powerful.

Electroplating

The first electrical machine used for an industrial process was a magneto, the Woolrich Electrical Generator.^[1] In 1842 John Stephen Woolrich was granted UK patent 9431 for the use of an electrical generator in electroplating, rather than batteries. A machine was built in 1844 and licensed to the use of the

Elkington Works in Birmingham.^[2] Such electroplating expanded to become an important aspect of the Birmingham toy industry, the manufacture of buttons, buckles and similar small metal items.

The surviving machine has an applied field from four horseshoe magnets with axial fields. The rotor has ten axial bobbins. Electroplating requires DC and so the usual AC magneto is unworkable. Woolrich's machine, unusually, has a commutator to rectify its output to DC.



Commutator of the Woolrich Electrical Generator

Arc lighting

Most early dynamos were bipolar^[note 1] and so their output varied cyclically as the armature rotated past the two poles.

To achieve an adequate output power, magneto generators used many more poles; usually sixteen, from eight horseshoe magnets arranged in a ring. As the flux available was limited by the magnet metallurgy, the only option was to increase the field by using more magnets. As this was still an inadequate power, extra rotor disks were stacked axially, along the axle. This had the advantage that each rotor disk could at least share the flux of two expensive magnets. The machine illustrated here uses eight disks and nine rows of magnets: 72 magnets in all.



de Méritens' 'ring wound' armature and single pole piece

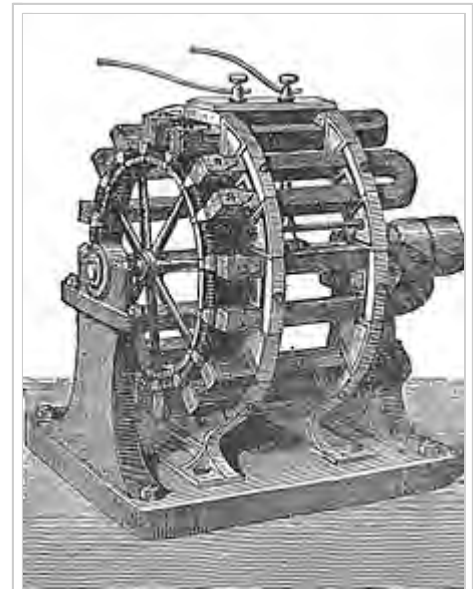
The rotors first used were wound as sixteen axial bobbins, one per pole. Compared to the bipolar dynamo, this did have the advantage of more poles giving a smoother output per rotation,^[note 2] which was an advantage when driving arc lamps. Magnetos thus established a small niche for themselves as lighting generators.

The Belgian electrical engineer Floris Nollet (1794–1853) became particularly known for this type of arc lighting generator and founded the British-French company Société de l'Alliance to manufacture them.

The French engineer Auguste de Méritens (1834–1898) developed magnetos further for this purpose.^[3] His innovation was to replace the rotor coils previously wound on individual bobbins, with a 'ring wound' armature.^[4] These windings were placed on a segmented iron core, similar to a Gramme ring, so as to form a single continuous hoop. This gave a more even output current, which was still more advantageous for arc lamps.^[5]

Lighthouses

de Méritens is best remembered today for his production of magneto generators specifically for lighthouses. These were favoured for their simplicity and reliability, in particular their avoidance of commutators.^[5] In the sea air of a lighthouse, the commutator that had been used previously with dynamo generators was a continual source of trouble. The lighthouse keepers of the time, usually semi-retired sailors, were not mechanically or electrically skilled to maintain these more complex machines.



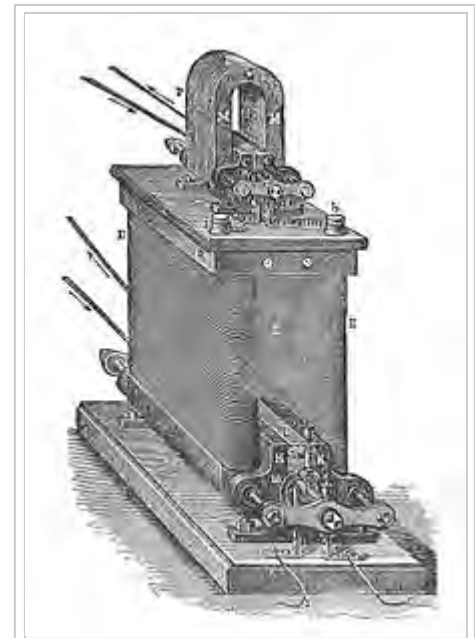
Auguste de Méritens'
lighthouse generator

The de Méritens magneto generator illustrated shows the 'ring wound' armature. As there is now only a single rotor disk, each horseshoe magnet comprises a stack of individual magnets, but acts through a pair of pole pieces.

Self-exciting dynamos

Both dynamos and alternators required a source of power to drive their field coils. This could not be supplied by their own generator's output, without some process of 'bootstrapping'.

Henry Wilde, an electrical engineer from Manchester, England, developed a combination of magneto and electro-magnet generator, where the magneto was used only to supply the field to the larger alternator. These are illustrated in Rankin Kennedy's work *Electrical Installations*^[6] Kennedy himself developed a simpler version of this, intended for lighting use on ships, where a dynamo and magneto were assembled on the same shaft.^[7] Kennedy's innovation here was to avoid the need for brushgear altogether. The current generated in the magneto is transmitted by wires attached to the rotating shaft to the dynamo's rotating field coil. The output of the dynamo is then taken from the stator coils. This is 'inside-out' compared to the conventional dynamo, but avoids the need for brushgear.



Wilde machine, where a small magneto (top) powers the field coils of a larger alternator below.

The invention of the self-exciting field by Varley, Siemens & Wheatstone removed the need for a magneto exciter. A small residual field in the iron armature of the field coils acted as a weak permanent magnet, and thus a magneto. The shunt wiring of the generator feeds some of its output current

back into the field coils, which in turn increases output. By this means the field 'builds up' regeneratively, although this may take 20-30 seconds to do so fully.^[8]

Although the use of magnetos here is now obsolete, separate exciters are still used for high power generating sets, as they permit easier control of output power. These are particularly common with the transmissions of diesel-electric locomotives.

Low-power magnetos

For their simplicity, particularly their independence from a stored power source, magnetos have found some use for low-power electricity generation, usually human-powered. The best known of these is the cycle lamp bottle dynamo. Despite their name, these dynamos were usually ^[note 3] AC magnetos.

Similar magnetos have also been used in hand torches. These used incandescent bulbs, and required continual hand squeezing to keep the magneto providing power. Between squeezes, rotor inertia sustained their output. Speed-increasing gear trains were needed

Early designs using LEDs and rechargeable batteries used dynamos much like small DC motors, but suffered from very short brush life. Small alternators with multipole permanent-magnet external cup rotors, combined with bridge rectifiers, offered long lives. Both single-phase and three-phase alternators are in use. Overcharge is possible, and to be avoided.

Future possibilities

The modern development of rare earth magnets makes the simple magneto alternator a more practical proposition as a power generator, as these permit a greatly increased field strength. As the magnets are compact and of light weight, they generally form the rotor, allowing the output windings to be placed on the stator, avoiding the need for brushgear.

Guided missiles

By the late 1980s, developments in magnetic materials such as samarium–cobalt, an early rare-earth type, allowed permanent magnet alternators to be used where an extremely robust generator is required. In guided missiles, such generators may replace the flux switching alternator.^[9] These need to operate at high speeds, directly coupled to a turbine. Both types share the advantage of the output coils being part of the stator, thus avoiding the need for brushgear.

Wind turbines

Small wind turbines, particularly self-build designs, are widely adopting magneto alternators for their generators. These use rotating neodymium rare-earth magnets with a three-phase stator, then a bridge rectifier to produce DC. This is then used either directly for water-pumping, stored in batteries, or used to drive a mains inverter which can supply the grid system for profit. These designs have been encouraged by one of the most popular self-build designs, described in Hugh Piggott's series of books and courses.^{[10][11]} A typical design here is an axial-flux generator recycled from a car brake disk and hub bearing. A MacPherson strut provides the azimuth bearing to bring the turbine into the wind.^[12] The brake disk, and its attached rare-earth magnets, rotates to form the armature. A plywood disk carrying multiple axial coils is placed alongside this, with a further iron armature ring behind it.

In large sizes, from the 100kW to MW range, the machines developed for modern wind turbines are termed permanent magnet synchronous generators.

[13]

References

- i. See the related bipolar motor for a discussion of their development from bipolar to multipolar fields.
- ii. Actually a higher AC frequency.



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- iii. A few late-model dynamos generated DC, usually by using an alternator and bridge rectifier rather than a commutator, so that they could charge batteries and thus maintain the lights when the bicycle was stopped at traffic junctions.

Magnetos
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