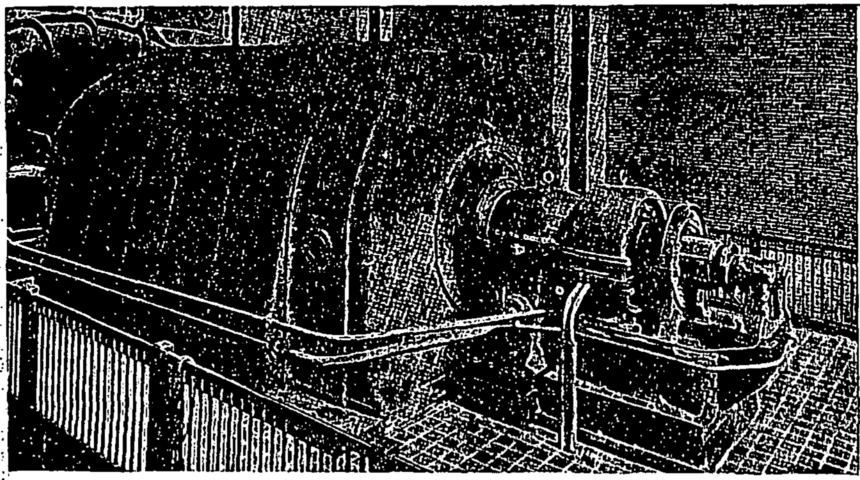
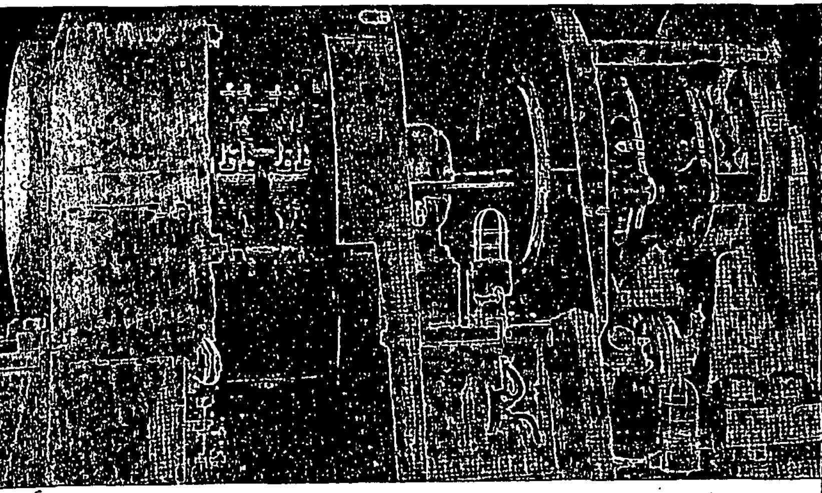


EARLY MAIN AND PILOT EXCITERS on turbine-generator sets were generally conventional dc machines adapted to fit the job. This photograph shows a 3600-rpm machine installed about the time of the first world war



EXCITER ACCESSIBILITY for maintenance of brushes has become progressively more important as service of power-plant equipment has increased. Closeup view of a modern exciter shows the ease with which brush rigging is reached

Turbine-Generator Exciters Keep Pace With Increased Operation

High-speed exciters are no longer a standard dc machine connected to the turbine-generator shaft. They give increased service, run as long as the main generator without shutdown

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▶ SHAFT-DRIVEN EXCITERS provide the commonest method of furnishing excitation for turbine-generators. The reason for their wide use is reliability of drive, and unity of construction and operation of turbine, generator and exciter. Any other source of excitation is subject to failure of the drive or other units introduced into the system. The one disadvantage of shaft-driven exciters is that the turbine-generator must be shut down, in case of trouble, to work on or remove the exciter.

Alternate methods of excitation have until recently used rotating dc machines, usually motor-driven, although sometimes separate small turbines have driven the exciters. With a separate system of excitation, an individual exciter for each ac machine, or a common exciter, has sometimes been used.

Before 1918, most 60-cycle turbine-generators were built for 1800 rpm. Exciter capacities were small, as generators themselves were not large. Because the exciters were small, it was not difficult to build shaft-driven exciters for either 1800 or 3600 rpm turbine-generators.

By 1918, 3600-rpm generators had been built in capacities up to 6250 kva, requiring direct-connected exciters of 50-kw rating. By 1919, 7500-kw sizes had been sold, ond in 1927 a unit was built for 3600 rpm, rated at 12,500 kva. This machine had a direct-connected 62½-kw exciter. To date, the largest 1800-rpm turbine-generator is 180,000 kva, with a 375-kw 250-v direct-connected exciter. The largest 3600-rpm unit is 111,800 kva and the largest direct-connected 3600-rpm exciter is 280 kw.

Early Machines. At first shaft-driven exciters were nothing more than open-type conventional dc machines, modified to suit operation of higher-speed units. Such machines were usually one- or *two-bearing type, driven from the end* of the generator shaft by a crude sort of flexible or solid coupling. At that time, turbine-generators, boilers and their auxiliaries were not very reliable. Units did not operate for sustained periods; shutdowns occurred in normal operation and gave sufficient time for regular maintenance work on the exciters. Photo above shows a 3600-rpm direct-connected turbine-exciter built about the time of the first world war.

Most manufacturers of large-sized central-station 3600-rpm turbine-generators have built direct-connected exciters in sizes up to about 150 kw. Beyond this rating some manufacturers have built shaft-driven exciters coupled to the turbine shaft by a reduction gear with exciters operating at about one-half turbine speeds. The reduction gear requires additional space for the unit; also, a speed of 1800 rpm means an exciter physically twice as large as that for 3600 rpm. The commutator peripheral speed of the 1800-rpm exciter is only about 20% lower than for the corresponding 3600-rpm unit. With correctly designed current-collecting parts—commutator and brush rigging are the heart of any dc machine—there is no reason to build geared exciters for present-day capacities.

As equipment improved, units could run continuously for longer periods. Exciters were, therefore, modified to give more accessibility for brush replacement, as in the photo above.

Direct-Connected Exciters. It is impossible to get brushes that will last from shutdown to shutdown so a new line of direct-connected turbine-exciters *has been designed for continuity of* operation. These use pedestal-type bearings, as shown above. To shorten the distance between bearings, armature diameters were made larger and the core length shorter. The ventilating fan was removed from the main exciter. Journal diameters wer- increased. These changes raise the critical speed, which has always been above operating speed, and add smoothness.

To simplify ventilation, the exciter was turned around with the commutator toward the ac generator. The ventilating fan has two sets of blades with a common discharge. Large blades cool the exciter and the smaller ones draw ventilating air over collector rings and brushes of the ac generator.

Exciter and pilot exciter are a complete unit on a new type of depressed bedplate. This permits removal of main and pilot exciters as a unit if the generator rotor has to be removed. Realignment is effected by simply setting the exciter back on the sole plate and inserting dowels. By depressing the bedplate and building the frame and pedestals on raised sections a large space is provided below the commutator. This new type of enclosed exciter gives more accessibility than open machines of comparable size.

Improved Service. *Since service* continuity is of prime importance, other factors that normally require maintenance on dc machines have been minimized or eliminated. Armature coils are brazed to commutator necks instead of soldered. This makes a joint as strong as the copper itself. Commutator necks are packed between and behind the bars with insulation so no creepage surface exists. This eliminates all surfaces for collecting flyash and coal dust. Rear end of armature windings, which are normally left bare, are completely insulated. The only surfaces on the rotor that can collect conducting material from the ventilating air are at the commutator necks and next to shrink rings. These are exposed and, when the unit is on slow roll, can be wiped off occasionally with a dry cloth. Other windings, usually of bare copper, are completely insulated with glass tape or other high-grade material.

Large-sized 1800- and 3600-rpm machines require shrink-ring commutators because of stresses in their high-speed operation. Shrink-ring commutators, built over 15 years ago, used massive rings for holding bars in place, binding them down on an insulated barrier on the shaft. Mechanically, such commutators would not fly apart; neither would they stay smooth through temperature cycles. Commutators, therefore, must be designed and constructed to go through temperature cycles and not have uneven bars. On the old construction, as the commutator heated up, the copper expanded, and one or more bars bowed outward slightly between rings. That type made no provision for longitudinal expansion.

The shrink ring of a modern commutator, drawing, p 72, is relatively small in section, and made of nickel-molybdenum steel. Rings are stressed so they always work within the elastic limit. These rings act like a rubber band around the commutator. As the commutator gets larger in diameter because of temperature expansion and