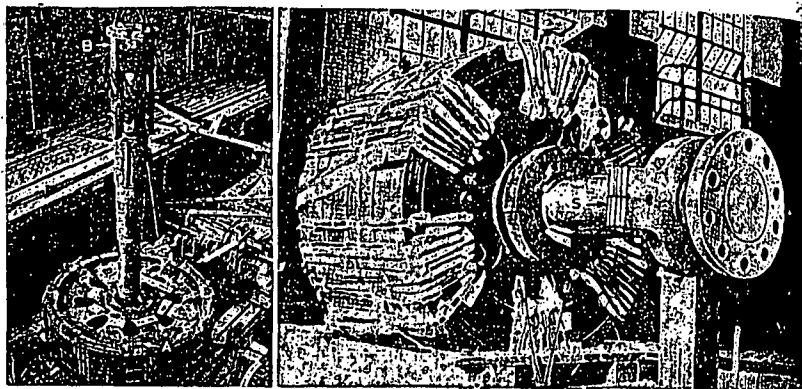




1 Setting shaft in cast-steel rotor's bore, expanded by induction heating 2 Horizontal-shaft assembly. Rotor made of four cast-steel sections had its bore heated to about 235 F by induction for removal from shaft, which was damaged

A Little Heat Eases Press-Fit Rotors on Their Shafts

Relatively small temperature increase may expand a large-rotor bore more than its press-fit tolerance. N L Rea, noted erection engineer, tells how to avoid trouble in the heating of these rotors for assembly on or removal from their shafts

► To COLD-PRESS-FIT a large flywheel or generator rotor on its shaft is a difficult and uncertain job. It is considerably simplified by heating the rotor or flywheel, and sometimes by cooling the shaft. Contrary to common belief, only a comparatively small increase in rotor temperature is needed for a sliding fit on a cold shaft. This temperature increase can be obtained by induction heating, electrical heaters, steam or hot water, as in the table.

Induction Heating. Temperature of 212 F will not damage even the lower-grade of electrical insulations, but will expand the bore of many rotor hubs to where they are larger than their shafts. Where a light press fit is required a rotor can be heated by induction so it slides on its shaft. For heavy press or shrink fits, induction heating

materially reduces the work of pressing a rotor on its shaft. This method heats rapidly, is clean and easily applied. It is especially helpful when removing a rotor from its shaft.

Heating by Induction is produced by electric currents induced in the rotor's outer surface, and not by resistance in the electrical conductors around the rim. It is therefore possible to heat and expand a rotor's rim and spider before the heat is conducted down into the shaft. We have obtained over 212-F rim-temperature rise before the heat reached the shaft. Expansion of the rim stretched the hub away from the shaft under these conditions.

Heating Winding. Fig. 1, shows the shaft being lowered into the bore of a cast-steel rotor expanded by induction heating. Heating was done by bare

250,000-cm cable, insulated from and wound around the rotor's rim between spokes and hub, as at A, and connected to a 60-cycle power source. Stop blocks B are lashed to the shaft to locate it correctly in the rotor hub.

All sections of the winding are wound in the same direction and connected in series to give them all the same polarity. This makes the rotor rim the equivalent of a single-turn secondary.

Experience proves there is no appreciable gain in putting the winding around the rim. Fig. 1 and 2, are winding the cable on the rim's circumference. Also, insulated cable can be used because heating is caused by eddy-current and hysteresis losses in the iron, and not from resistance losses in the cable.

Electric-Oven Heating. Induction heating

should not be applied to steel-plate rotors because the heat buckles and distorts the plates. Heat such rotors in a temporary oven of packing-case lumber lined with sheet iron or batters. Make the oven large enough to fit over the piece to be heated. In electric heaters 5- to 10-kw is enough to heat the largest rotor. Baffle the oven with sheet iron so the rotor is heated by air circulation and not direct radiation from the heaters. This insures uniform heating and avoids damaging the rotor by unequal heating in the different sections.

Checking Bore Expansion. Provide the heating oven with a small hatch so the bore's expansion can be checked without stopping the heating operation. Make a pin gage to fit the bore before starting the heating. Keep the gage lying on the shaft when not in use so it remains at shaft temperature. Check the bore's expansion with feelers between one end of the gage and bore.

Electric Heaters. Any available heaters can be used if applied intelligently. One large rotor was covered with tarpaulins and seven 750-watt lamps hung between the rotor's spokes several days. These provided enough heat to expand the rotor so it would slide easily onto the shaft.

If heaters are not available they can be made from iron telephone wire. Wind 100 turns on a 1/2-in. pipe mandrel. Slip the coil off the mandrel stretch to separate the turns and try it on 115 v. It should take about 10 amp and get nearly red hot. If it doesn't, shorten or lengthen the coil to get satisfactory temperatures and make additional coils like the sample. String porcelain knobs on iron rods or attach them to a strap-iron framework with insulators on stove bolts and connect enough coils in multiple to give required heater capacity.

Another method is to thread porcelain knobs on three concentric rings,

Fig. 3. Here four 400-ft telephone wires in multiple on 115 v take about 35 kw. At frequent intervals tie the wires together and to the knobs.

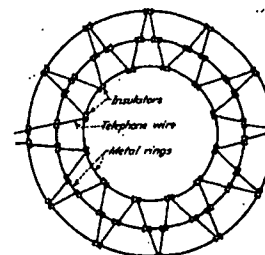
To use the heaters, support the rotor horizontally on blocking with the heaters placed 90 deg apart around it, with sheet-iron baffles between the two. Have the baffles extend vertically to top of rotor. Lower a square oven box over rotor and heaters, and natural air circulation will transfer the heat evenly to all parts of rotor.

A standard transformer drier that takes heated air from the bottom of the oven box and delivers it to the top has been used to advantage.

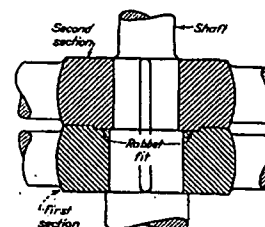
Vertical-Shaft Rotors. To assemble a vertical-shaft rotor, first up-end the shaft and bolt it to the dummy coupling plate in the assembly pit if the station has one, as it should. Otherwise, set the coupling in some convenient spot that carries weight of complete rotor, protecting the coupling face, and block the shaft securely, Fig. 5. Center the shaft as nearly vertical as conditions permit. Place stop blocks on the coupling to locate rotor on shaft correctly, if the latter does not have a shoulder for this purpose. It may require several hours for the rotor to cool enough to grip the shaft, so make sure it is supported in the correct location. One erector neglected to put stop blocks on the shaft and had to hold the rotor with the crane several hours before he dared slack off.

Adjust slings on the rotor's first section until it hangs level, then lower it over the shaft end far enough to center the bore on the shaft. Rotate the rotor to align key and keyway. Put match marks of white paint or chalk on end of crane and its track, and on crane carriage and girder where the crane man can see them. This saves time when lowering the hot section on the shaft.

Put the rotor with the slings on its



3 Heater unit. Heater wire and insulators assembled on 3 concentric rings



4 Rabbit in hub. If hub has a rabbit, chip it out before starting assembly

support and place the heaters around it and heat until the bore has expanded the required amount. Place the thrust block in the oven so it will expand if it must be used as a strong back should the hot rotor hang up on the shaft. Arrange jacks and blocking for instant use. When bore has expanded, lubricate the shaft, lift off the oven box and quickly lower rotor over shaft.

Heating the Rotor. Adjust the slings on next section and heat at least 24 hr, or until shaft and first section cool to room temperature.

Check hubs of all sections, which may have rabbit fits for manufacturing purposes. If rotor sections have a rabbit like Fig. 4, chip out the recess or cut off the spigot so clearance is ample to take care of expansion of the heated section. Shaft and keys locate and hold the rotor sections in correct relation so the rabbit fit serves no purpose after shop machining.

Rotor-Section Expansion. Remember that the rotor sections expand in length as well as in diameter. Weight of the first section holds it down against the shaft shoulder or stop blocks as it cools. The first section being cold chills the lower end of the next hub

Relatively Small Increase in Temperature of Rotor May Expand Its Bore More Than the Press-Fit Tolerance

Heating method	Bore dia, in.	Pressing allowance, in.	Bore expanded, in.	Oven temp, F	Room temp, F
Electric oven.....	30	0.005	0.040	356	86
Electric oven.....	18	0.012	0.030	275	68
Electric oven.....	30	0.005	0.032	248	68
Electric oven.....	40	0.017	0.025	237	77
Boiling water.....	24	0.015	0.023	212	68
Steam Box.....	24	0.017	0.022	212	68