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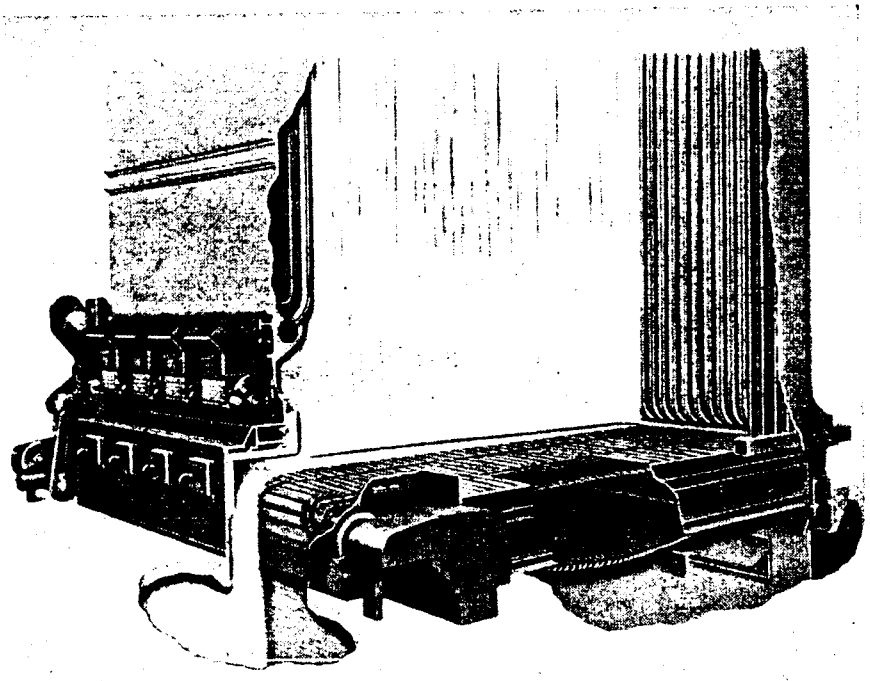
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## FURNACE DUST FLOWS IN SET PATTERNS...

**Simplest flow sees coarser dust drop out in first boiler pass, with bulk of stack cleaning left to dust collector**

**▶ Partial reinjection feeds some dust back to the spreader-stoker grate, salvages heating value from waste**

**Total reinjection increases dust loading; collector must be more efficient**



**Spreader-stoker firing** results in 33% of the ash leaving the furnace as flue dust, so controls over the dust paths are one way to reduced stack discharge

# Spreader Dust Responds to Controls

By **ELMER R KAISER**, *Asst Director of Research, Bituminous Coal Research, Inc*

STACK-DUST CONTROL for spreader stokers requires: (1) good design (2) good operation (3) external aids in the form of dust collectors. With each requirement playing its proper part the spreader stoker can easily meet the usual limits of dust emission set by local air-pollution ordinances.

In practice, particularly with units already operating, these three control factors may fall short of the ideal balance. Real problems like space limitations, dollar cost of a collector installation, penalty and nuisance of dust disposal and, to some extent, possible heat recovery from unburned carbon influence purchase of dust collectors.

**Design.** Importance of furnace space in completing combustion has been recognized since the early work of Kreisinger. In fact, today it is quite generally accepted. Enough space permits establishing the favorable conditions of time, temperature, turbulence and proper available oxygen.

With older, already installed boilers, the basic conditions are often not met. Usually furnace temperature gets high enough and the proper oxygen can be made available. But often low-setting heights and otherwise inadequate combustion space limits the available time. The excellent work of Engdahl, Major[1], et al, on furnace jets has gone a long way toward correcting this weakness.

They found locating jets about 12 in. above the fuel bed, and in some instances lower, gives particularly good results. For conditions requiring turbulence over the full grate of a stoker, jet nozzles in opposite walls spaced about 24 in. apart meet the bill. More details on jet design and location can be had from other sources.

**Reinjected Dust.** But there is still another control factor that effectively lengthens available combustion time and also reduces stack-dust loading. That is a system of dust or cinder reinjection employing dust collectors.

A plant actually can do one of three things: (1) Trap and collect all possible dust, and dump as refuse. (2) Reinject all cinders removed in boiler passes for refiring, and dump all dust at the collector stage. (3) Return all collected dust to the furnace and have only fine ash to dispose of. Since we are concerned with increasing available combustion time as well as controlling stack-dust loading, we'll consider only the last two—partial or complete reinjection. Here are influencing elements.

**Overfire Jets.** The basic furnace and dust-reinjection system shows in Fig. 1. By rearranging the piping from boiler pass A and dust collector B to the furnace proper, the amount of dust reinjected can be changed from partial to total. Overfire air jets are included because they are essential to good operation with reinjected dust. But their actual location and number can be varied for best results.

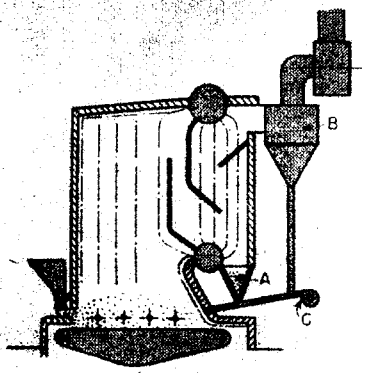
**Dust Return.** Reinjected dust must enter the furnace so it can land on the fuel bed. If not, all particles will be lifted right out of the combustion chamber in short order. Fine dust in particle form sticks to the fuel bed in one of two ways: either by being wedged or held in place under or between larger pieces of ash or by lying adjacent to larger pieces away from high air and gas-stream-velocity paths.

In the high-temperature zone near the top of the fuel bed fine ash particles tend to sinter or fuse into heavier pieces that remain on the bed.

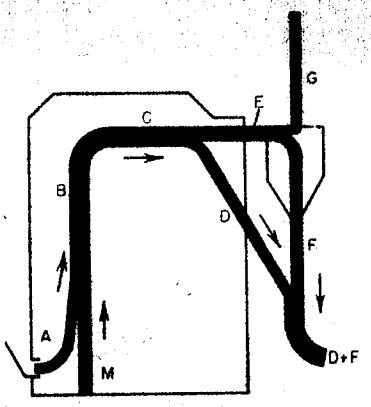
A series of tests with 1¼ by 0 in.

(1) R B Engdahl, W S Major, Technical Report VI. Bituminous Coal Research Inc, 2609 First National Bank Bldg, Pittsburgh 22, Pa.

# STEP-BY-STEP DEVELOPMENT OF SPREADER-STOKER HOT PAPER SHOWS

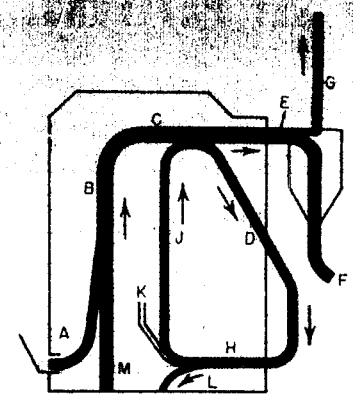



**1** Simplified furnace shows last pass hopper, dust collector, reinjection




(a) Without refiring

**2** With no reinjection at all dust path follows straightforward course above




(b) Partial refiring

**3** Partial reinjection complicates dust paths but promises some advantages

## I: DUST-LOAD CHANGES WITH REINJECTION

| | Without refiring, % | Partial refiring, % | Total refiring, % |
|---|---|---|---|
| Required efficiency of dust collector | 70 | 74 | 90 |
| Efficiency of boiler-pass hopper | 30 | 29 | 25 |
| Ash content, stack dust | 60 | 65 | 80 |
| Ash content, collector dust | 45 | 48 | 65 |
| Ash content of dust from boiler-pass hopper | 33 | 34 | 45 |

## II: HOURLY BOILER DUST WITHOUT REFIRING

| | Total Pounds | Pounds Ash | Pounds Combustible | Percent Ash | Percent Combustible |
|---|---|---|---|---|---|
| G given | 67 | 40 | 27 | 60 | 40 |
| F G × 0.70/0.30 | 156 | 70 | 86 | 45 | 55 |
| E = F + G | 223 | 110 | 113 | 49 | 51 |
| C = E/(1.00—0.30) | 318 | 141 | 177 | 44 | 56 |
| D = C—E | 95 | 31 | 64 | 33 | 67 |
| A given | 125 | 25 | 100 | 20 | 80 |
| M = C—A | 193 | 116 | 77 | 60 | 40 |
| B = C | 318 | 141 | 177 | 44 | 56 |
| D + F | 251 | 101 | 150 | 40 | 60 |

## III: HOURLY SUMMARY OF DUST

| | | Without refiring | Partial refiring | Total refiring |
|---|---|---|---|---|
| Dust: | refired, lb | 0 | 92 | 826 |
| | lost to stack, lb | 67 | 67 | 67 |
| | lost to refuse, lb | 251 | 190 | 0 |
| | lost, total, lb | 318 | 257 | 67 |
| | percent of coal fired | 6.4 | 5.1 | 1.3 |
| Ash: | refired, lb | 0 | 31 | 493 |
| | lost to stack, lb | 40 | 43 | 54 |
| | lost to refuse, lb | 101 | 91 | 0 |
| | lost, total, lb | 141 | 134 | 54 |
| | refired, left on grate, lb | - | 7 | 87 |
| Carbon: | refired, lb | 0 | 61 | 333 |
| | lost to stack, lb | 27 | 24 | 13 |
| | lost to refuse, lb | 150 | 99 | 0 |
| | lost, total, lb | 177 | 123 | 13 |
| | refired and burned, lb | - | 54 | 164 |
| | Carbon loss, % total Btu in coal | 4.0 | 2.7 | 0.3 |
| | Steam gained, lb | - | 500 | 1510 |

**What's the dust loading in lb per 1000 lb of flue gas?**

**How much ash is refired?**

**What's the percentage of carbon that's recovered?**

**These tables supply the answers**

coal on a spreader-fired locomotive had 80% of the cinder carryover caught in a collector. By reinjecting into the firebox at a low level about half the cinders hurt [illegible] refiring. Most of the cinders left the ash behind on the fuel bed as large pieces. About 43% of the ash in the original cinder was recovered in this way with a firing rate of 45-50 lbs per sq ft per hr.

**Coal Size.** Primary cinder, Fig. 1, goes way down in quantity with a double-screened coal. It can [illegible] or triple with a ⅜ by 0 in. coal. Doubling the primary dust increases dust loading about 25 lb per hr. To effectively remove this added load from the gas stream the collector has to increase its efficiency 18-23%. Yet the price advantage between the double-screened coal and the smaller coal is such that it may well be worth the extra trouble.

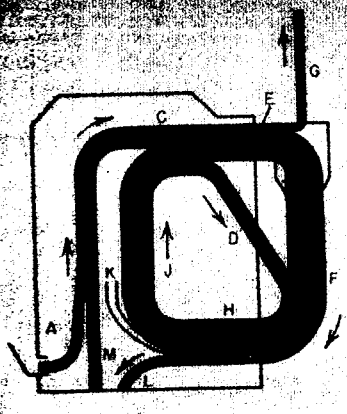
A second and less desirable way of meeting the problem is to continuously withdraw to refuse a fraction of the collector catch. Wasting 50 lb an hr or one eighth the catch of a single collector removes the extra 25 lb of ash an hr.

Still another possibility would be two dust collectors in series. Dust in the second collector would run at least 80% ash and could be dumped to refuse. Many plants use mechanical dust collectors followed by electrostatic.

**Firing Rate.** Once firing rate gets above 20 lb per hr per sq ft, each increase after that raises the dust loss from the furnace. More primary cinder and flyash result because more coal is fired. It's as simple as that.

In addition the higher air rate through grate and furnace entrain larger and heavier particles.

Without reinjection, rate of dust emission above half load increases by about the 1.4 power of the firing rate.[3] Increasing the excess air through the grate raises flow rates and shortens available combustion time for particles in the furnace. Flow rates through the fuel bed that cause the particles to




(c) Total refiring

**4** Total refiring increases loadings to the limit of collector efficiency

## PATH IDENTIFICATION

- **A** Primary cinder
- **B** Total new dust
- **C** Total furnace dust
- **D** Catch of boiler-pass hopper
- **E** Dust to collector
- **F** Collector catch
- **G** Stack dust
- **H** Refired dust
- **J** Recirculating dust
- **K** Refired combustible burned
- **L** Refired ash to grate
- **M** Dust loss from grate

## IV: HOURLY BOILER DUST WITH TOTAL REFIRING

| | Total Pounds | Pounds Ash | Pounds Combustible | Percent Ash | Percent Combustible |
|---|---|---|---|---|---|
| G given | 67 | 54 | 13 | 80 | 20 |
| F = G × 0.90/0.10 | 603 | 392 | 211 | 65 | 35 |
| E = G + F | 670 | 446 | 224 | 67 | 33 |
| D = E × 0.25/0.75 | 223 | 101 | 122 | 45 | 55 |
| H = F + D | 826 | 493 | 333 | 60 | 40 |
| C = E + D | 893 | 547 | 346 | 61 | 39 |
| A from Table II | 125 | 25 | 100 | 20 | 80 |
| M from Table II | 193 | 116 | 77 | 60 | 40 |
| B from Table II | 318 | 141 | 177 | 44 | 56 |
| J = C — B | 575 | 406 | 169 | 71 | 29 |
| K + L = H — J | 251 | 87 | 164 | 35 | 65 |
| L = 0.44 B — 0.80 G | 87 | 87 | — | 100 | — |
| K = H — J — L | 164 | — | 164 | — | 100 |
| C = B + J | 893 | 547 | 346 | — | — |

L/0.65 H = 18% ash recovery on grate

K/0.40 H = 49% carbon recovery

## V: HOURLY BOILER DUST WITH PARTIAL REFIRING

| | Total Pounds | Pounds Ash | Pounds Combustible | Percent Ash | Percent Combustible |
|---|---|---|---|---|---|
| G given | 67 | 43 | 24 | 65 | 35 |
| F = G × 0.74/0.26 | 190 | 91 | 99 | 48 | 52 |
| E = G + F | 257 | 134 | 123 | 52 | 48 |
| D = E × 0.29/0.81 | 92 | 31 | 61 | 34 | 66 |
| H = D | 92 | 31 | 61 | 34 | 66 |
| C = E + D | 349 | 165 | 184 | 47 | 53 |
| A from Table II | 125 | 25 | 100 | 20 | 80 |
| M from Table II | 193 | 116 | 77 | 60 | 40 |
| B from Table II | 318 | 141 | 177 | 44 | 55 |
| L = 0.44 B — 0.65 G — 0.48 F | 7 | 7 | — | 100 | — |
| J = C — B | 31 | 24 | 7 | 77 | 23 |
| K = H — L — J | 54 | — | 54 | — | 100 |

L/0.34 H = 23% ash recovery on grate

K/0.66 H = 88% carbon recovery

...ve and teeter in the fuel bed increase ... losses because very little if any ... ash particles can be trapped ... bed itself.

**Boiler Paths.** The simplest dust-flow ... with spreader stokers employing ... dust collector shows in Fig. 2. ... case with no reinjection, *A* and ... are the only dusts entering the boiler ... The coarser dust, *D*, drops into ... boiler pass to reduce dust loading ... collector, *E*. Here a portion of ... finer ash dust escapes to the stack ... stays behind.

... partial reinjection, Fig. 3, some dust, *D*, reenters the lower part of the furnace a short distance above the fuel bed. With this dust projected at an angle toward the grate some of it, *L*, stays on the grate and some of the combustible, *K*, burns out of the cinders on either the grate or in the furnace space. Whatever doesn't burn or stay on the grate, *J*, leaves again with the the furnace ...

Total reinjection, Fig. 4, produces heavier dust loadings than any other method. Only a minor fraction of reinjected ash deposits on the grate. And only a part of the returning cinder burns in each cycle. Finally at a given firing rate, dust loading reaches a point of equilibrium. A dust collector of higher efficiency is needed to keep stack-dust load below nuisance level. There is, however, an upper limit to collector efficiency so the dust loading has to stay within that range to avoid offending the usual smoke ordinance.

**Expected Results.** From a study of design factors and published data the probable weights of dust passing through the boiler can be figured for the three methods shown in Fig. 2-4. For comparison purposes a 45,000-lb-per-hr spreader stoker, firing coal at a constant rate of 5000 lb per hr, serves as the guinea pig. Its stack-dust loading must stay below 0.85 lb per 1000 lb of flue gas, corrected to 50% excess air to meet the most stringent smoke ordinances.

Coal for the boiler is 13,200 Btu, 1¼ by 0 in. size, 10% ash content with 5% minus 20-mesh particles. Gas velocities at a firing rate of 40 lb per sq ft per hr (total 5000 lb per hr) can entrain these particles of minus 20 mesh. All that these particles lose in the furnace is moisture, most volatile, a minor amount of fixed carbon. Because of this we assume the particles lose half their weight on their first flight so the remaining bit has an ash content from 10 to 20%.

All heavier coal pieces burn on the grate. Some flyash and carbon leave in the gas stream in an assumed ratio of 60% ash to 40 % carbon.

At 35% excess air, 66,100 lb per hr of air flows through the furnace. Jets supply 5% of this excess over the fire. For calculation purposes the total gas becomes 78,500 lb per hr at 50% excess air (12% $CO_2$). For legal dust emission, maximum allowable dust by weight is 67 lb per hr.

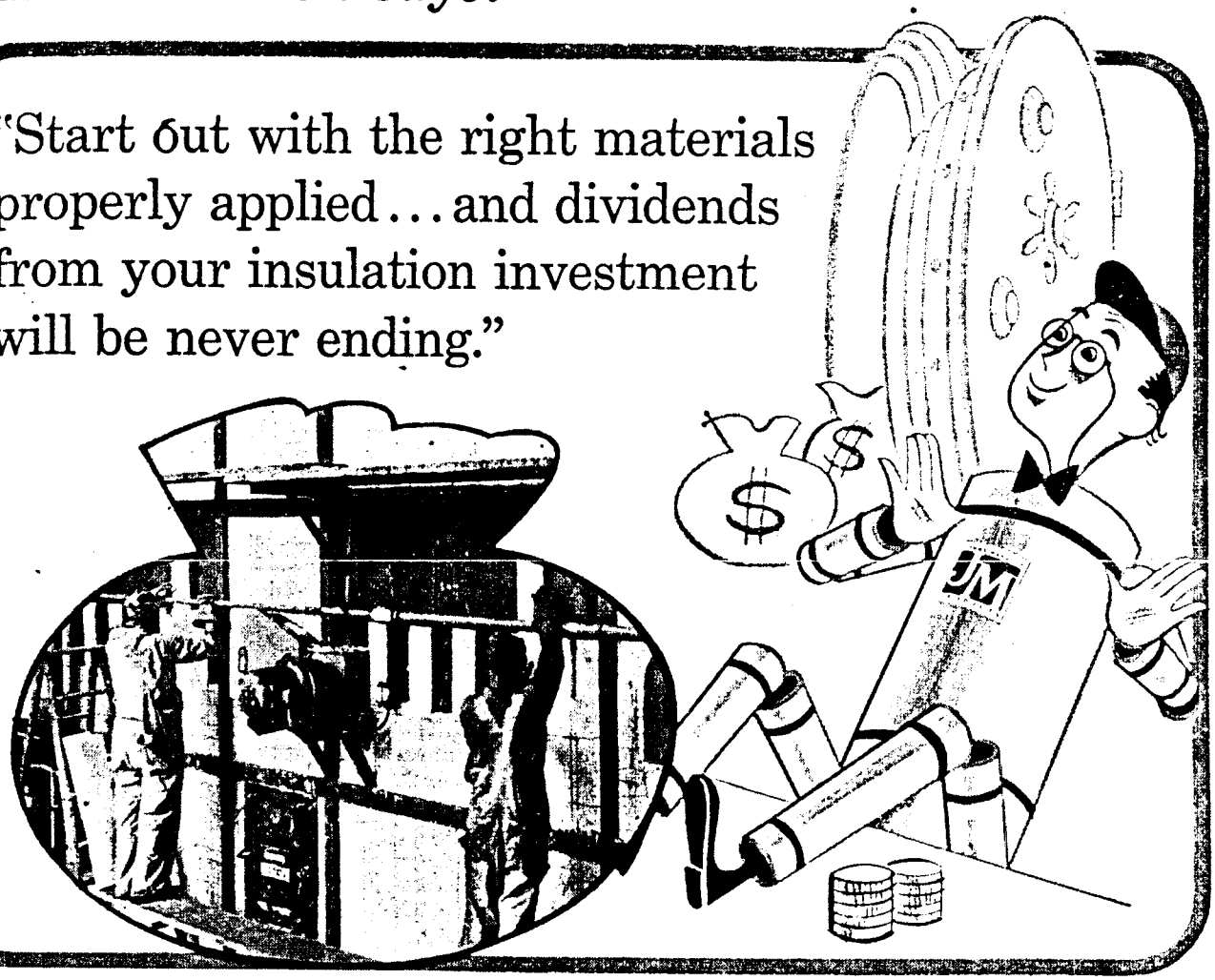
Now let's see what effect reinjection has on stack-dust loading. We know with reinjection a more efficient dust collector must be used. Further, the boiler-pass hopper removes fewer cinders as proportion of finer dust from reinjection increases. Table I lists the changes in the principal factors we have to deal with in compa... g performance. The collector efficiency shown is an over-all measure for the size consist and class of dust entering the collector.

**Dust Flows.** For our example boiler, the loadings of each section of the different dust paths have been calculated, Tables II, IV, V. In addition, the proportions of refired ash, *L* and combustibles, *K*, not reappearing, are worked out at the bottom of Tables IV, V. Ash and combustible quantities plus their individual percentages make up the rest of the data shown.

This article is based on "Dust Emission From Coal-Fired Boiler Furnaces," presented before the Midwest Power Conference, Chicago, Ill., April 1951, and the Air Pollution and Smoke Prevention Association of America, Roanoke, Va., May 1951.

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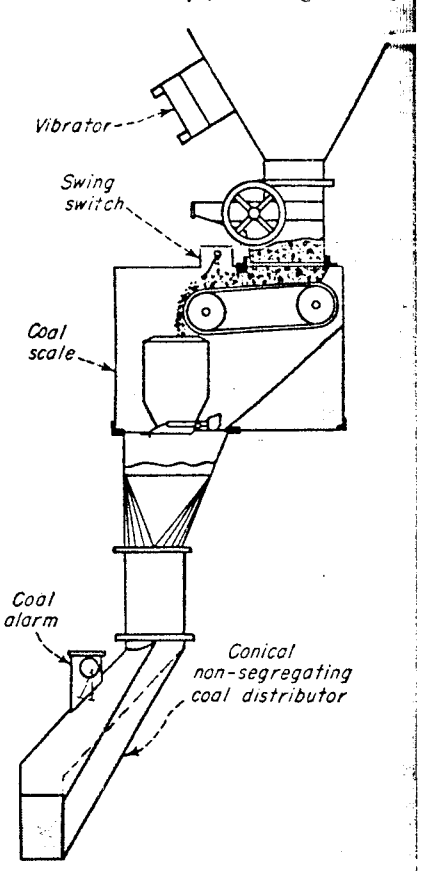
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# More PLANT PROBLEMS

Begins on page 134

switch can be arranged to automatically start a vibrator at bunker outlet when there's no coal on scale feed belt. It will also stop vibrator as soon as coal flow starts again. This eliminates noise of continuously-running vibrator. It also prevents packing of coal at bunker outlet. Many plants run well with this arrangement.

Similar alarm can also be installed on upper part of coal distributor; see sketch. As *LS* says, clearing bunker




jams will probably stop downspout jams. But alarms in both places are useful. These units are standard equipment available from downspout manufacturer.

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**General Electric Co** has received an order for a 180,000-hp wind-tunnel drive—the greatest power output ever concentrated on a single shaft—for installation at the National Advisory Committee on Aviation's Ames Aeronautical Lab at Moffet Field, Calif. The drive consists of four 45,000-hp 720-rpm variable-speed induction motors mounted in tandem on a single shaft to drive either of two axial-flow compressors.

**Westinghouse Electric Corp's** new plant at Union City, Ind., for ½- to 1/20th-hp motors will produce 75,000 units a month when it goes into production. The Small Motors Div has tripled its output.