A METHOD OF EMULATING BURNER TILTS IN PEPSE BOILER MODELS

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ABSTRACT

Modern fossil fired boilers are operated using control techniques to regulate steam temperatures, flow rate and pressure. A very effective control of steam temperatures is burner tilts in conjunction with attemporation spray.

This paper presents a method successfully employed by Kentucky Utilities Company to emulate the use of burner tilts on Combustion Engineering Boiler models. Also described, are some basic definitions of the boiler operating states and a field test procedure to correlate actual furnace tilt position to the tilt controls of a PEPSE boiler model.

TILTS AND REHEAT TEMPERATURE

Tilts on Combustion Engineering boilers are used to control hot reheat steam temperatures. Superheat steam temperatures are controlled by superheat attemporation flow. Rarely will reheat attemporation spray be used, since this will adversely affect boiler efficiency. Superheat attemporation on the other hand has little or no impact on boiler performance.

When burner tilts are employed to control reheat steam temperatures, both reheat and superheat steam temperatures are affected. Essentially, if the boiler master detects a low hot reheat temperature, it will raise the burner tilts and consequently the furnace fire. This puts more heat into the convective pass to raise the reheat steam temperatures. High reheat steam temperatures have just the opposite effect. A side effect of this control action is the change of furnace firing rate and the change of superheat steam temperatures. Firing rate is determined by the amount of steam demand required at a given pressure. When the tilts are raised, the furnace heat flux is redistributed over a smaller furnace area. Depending upon the cleanliness of the water walls, this causes an increase in firing rate to increase the heat transfer, thus maintaining the constant steam production. This also amplifies the intended effect of raising the tilts. The opposite is true also and the firing rate diminishes with lowered tilt position. Perhaps the most interesting effect of tilt control is that superheat steam temperatures are more affected than are reheat temperatures. For example, if tilts are raised, the firing rate will increase , the reheat steam temperature will increase and the superheat steam temperature will increase to a greater extent then the reheat temperature. This effect can be plotted on a TILT-TEMPERATURE graph as shown in **figure 1.**

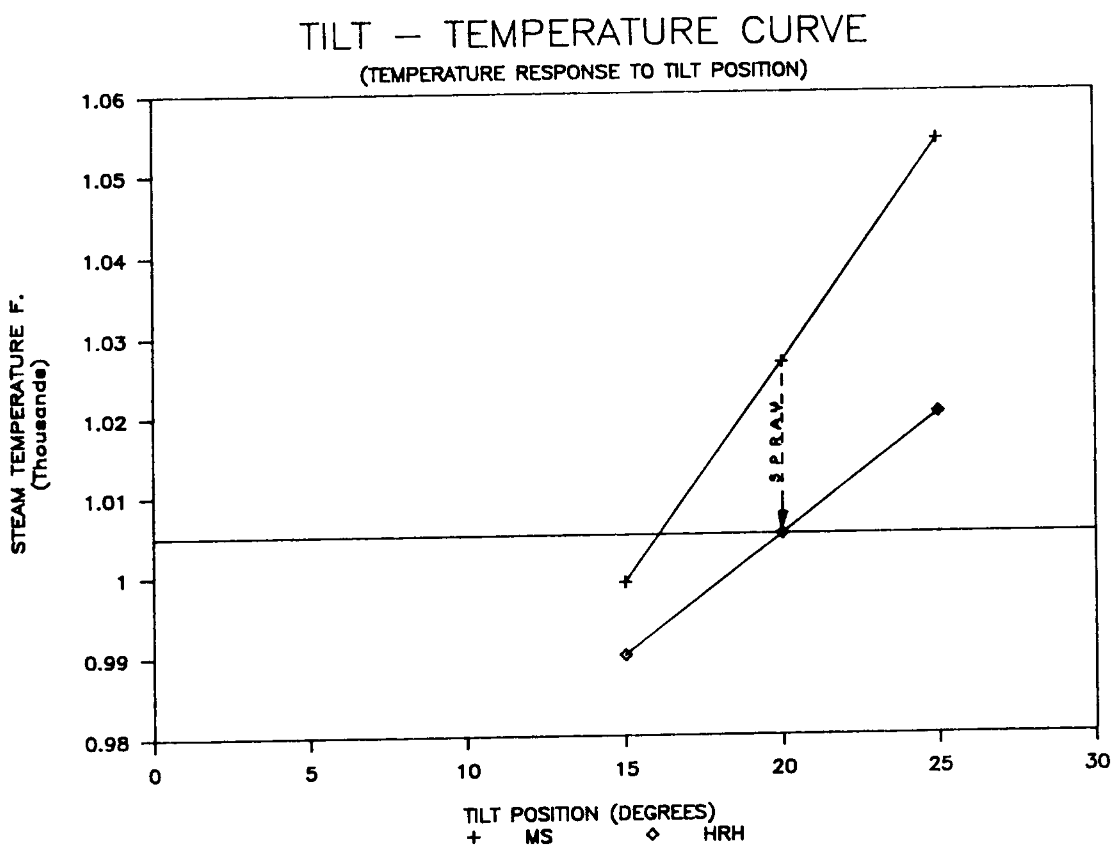


figure 1

The control scheme employed is then to add superheat spray to bring the superheat temperatures down to the desired temperature to where both steams are balanced in temperature (Balance Point) at approximately 1005 F. This plot also shows why superheat steam temperature is not controlled by tilt position. If it were, then once the desired temperature is reached (1005.0), it would be impossible to bring the reheat temperature up to achieve a balance point, unless reheat surface is added. (Not a good control scheme.)

TILT CONTROL EMULATION METHOD

In May 1986, Kentucky Utilities Company found it necessary to perform surface studies on the E. W. Brown 3 boiler. To do so, required the use of tilts in the PEPSE boiler model. It was necessary that the models tilt control accurately simulate what was occurring in the boiler.

To emulate tilt control, we chose to use the variable (RHLL) in the radiant components of the models water walls of the furnace. The variable (RHLL) represents the effective tube length of the water walls. Essentially, the idea was, and still is, to shorten the tube length to raise the tilts and to lengthen the tubes to lower the tilts. This scheme worked extremely well. In the boiler model, this action causes the effective heat transfer surface to be reduced upon raising the tilts. This increases the firing rate to maintain steam production and concurrently throws more heat into the convective pass. The opposite is true as well. In reality, the furnace heat transfer surface is not reduced; however, the heat flux for steam production is moved into an effectively smaller area as tilts are raised. This procedure was later modified by breaking up the water wall radiant component into two or more components and placing the control on one of these components, while using the others to simulate furnace fouling.

SETTING THE MODEL TILTS

Once all boiler test data is entered into the working model, the boiler model is then used in performance mode to determine the fuel firing rate. This is done by controlling firing rate to achieve either measured economizer gas temperature or cold end temperature, whichever is believed to be most accurate. After this step, the firing rate is set in the model. Next, the furnace radiant components are changed from performance to design mode. It is important that the pressure drop in the water wall components remain fixed. Also, it is important that there are no specified heat transfer coefficients or multipliers for this sum. If the water walls have been divided into, say, two components, then fix the tube length (RHLL) of the radiant water wall component you intend to use for tilt control to some convenient length, such as 30.0 feet. The other water wall radiant component then represents the balance of the water wall tube length which PEPSE will determine. Now run the model, controlling that second water wall component (RHLL) to achieve a quality of 1.000 for the steam leaving the steam drum moisture separator. This will establish the remainder of the effective WW tube length less the length set for tilts control. Enter this controlled (RHLL) into the second WW component. You should note that the furnace exit gas temperature and the economizer gas temperature are the same as they were in the performance mode run. At this time, the values for heat transfer coefficient for the radiant components can be found in the "Detailed Heat Exchanger Design Output". These values should be input to the radiant component data cards. If these values are not hard wired in, the use of this strategy for tilt control will probably not work. This is because the total radiant energy in a PEPSE furnace model appears to be fixed if the heat transfer coefficients are not established. Thus, if you reduce surface area in one component the radiant heat is redistributed, but doesn't leave the furnace as convective heat.

When this step is completed, the tilt control should be ready for use. The components in the convective pass should be placed in design mode and for each model run, the firing rate must be controlled or adjusted to give a quality (XX) = 1.000 for the steam leaving the drum moisture separator. Otherwise, the model results will be meaningless.

CORRELATION OF MODEL TILTS TO BURNER TILTS POSITION

Boiler Tests

PEPSE boiler model tilt control using radiant water wall component (RHLL) is surprisingly sensitive. A change of 2 or 3 feet of RHLL will have a significant effect on the change of steam temperatures and firing rate. The problem is that unless tests are run to correlate the tilt position in degrees to RHLL in feet, you could easily exceed the physical limits of the actual boiler with the computer model.

A procedure we have used with success is to run the correlation test immediately after the boiler test data is taken. First of all, one correlation point can be established during the boiler test by placing the tilts on hand and recording their position. This value in degrees will be equivalent to the RHLL value set in the balanced model described above. At least one and preferably two additional points should be established for reference. The procedure used is as follows:

(1) Record all boiler boundary data and as much header data as possible during the test; fuel analysis etc.
(2) Once the boiler test is complete, request the unit operator to place all spray flows and tilt controls on hand.
(3) Request the operator to maintain constant attemporation flow regardless of team temperatures. Also maintain constant main steam flow.
(4) Move the tilts + or - 10 degrees and let the unit stabilize for 30 minutes or more. Let all swings dampen out.

(5) Critical data to be recorded for tilt studies are:

- Main Steam Temperature & Pressure
- Reheat Steam Temperature & Pressure
- Feedwater to Economizer Temperature
- Cold Reheat Steam Temperature
- Economizer Gas Outlet Temperature

(6) Repeat steps 3 and 4, if possible.

It is advisable to visually verify the tilt position at the boiler, not just in the control room. We found tilts that needed to be moved by hand and were not following what was indicated on the position display.

PEPSE MODEL TEST & CORRELATION

The correlation is accomplished by running the PEPSE boiler model and comparing the boiler test data to the model output using the test data steam temperatures as a reference point for comparing boiler to model tilt positions. Verification of the resulting correlation can be accomplished by comparing the measured economizer gas outlet temperatures to the computer model gas temperatures at these points. An example of this process goes something like this:

(1) Balance the boiler test data in the model and set a convenient value for tilt (RHLL) as described in the previous section "Setting the Model Tilts". Let's assume some data:

	RHLL = 30'
	TILT = + 10 DEGREES (from boiler test)
BASE BOILER TEST	MAIN STEAM TEMPERATURE = 1002.0
	REHEAT STEAM TEMPERATURE = 1006.0
	ECONOMIZER GAS TEMP = 675.0

(2) With the boiler balanced in Design Mode, change the feedwater temperature and the cold reheat steam temperature to the temperatures measured in the first tilt test following the boiler test. If tilts were lowered for this test, then arbitrarily select a new value for RHLL that models a tilt movement in that direction, say - RHLL = 33'. Run the model and control the firing rate to give a quality of steam of 1.000 at the moisture separator. Then log the results from the PEPSE run.. Again, let's assume some data.

	RHLL = 33'
ARBITRARY MODEL	FW & CRH TEMP = as measured.
TILT RUN	MAIN STEAM TEMPERATURE = 940 degrees
	HOT REHEAT STEM TEMPERATURE = 980 degrees
	ECONOMIZER GAS TEMPERATURE = 652.7 degrees

After the first arbitrary model tilt run, you can repeat this procedure for second and subsequent tilt tests repeating step 2. Let's assume we arbitrarily selected 28' for a second tilt run, after resetting the feedwater and cold reheat temperature.

	RHLL = 28'
ARBITRARY MODEL	FW & CRH TEMP = as measured
TILT RUN	MODEL MAIN STEAM TEMP = 1050.0
	MODEL HOT REHEAT STEAM TEMP = 1016.6
	ECONOMIZER GAS TEMP = 660.13

Plot this data on a tilt position - steam temperature graph to note the curves representing main steam and reheat steam temperatures as a function of RHLL. You will note that the main steam temperatures fall on a straight line, as well as the reheat steam temperatures. Next, locate where the main steam temperature from the first tilt test falls on the main steam line and do the same, using the reheat temperature on the reheat line. If the data is accurate, both points will be at the same tilt position of the model. If not, then the mean of the two indicated tilt positions indicates the correlation between the measured tilt in degrees and RHLL. This procedure can be followed for the second tilt test to pick up a third correlation point. **(figure 2)** To verify the correlation, set the model tilts at the two test correlation points and compare the results of the model economizer gas temperature to the measured data. This comparison should be reasonably close. It is then a simple matter to plot RHLL vs. tilt position in degrees to arrive at a correlation curve.

SUMMARY

The use of radiant component (RHLL) to emulate burner tilts is a simple and effective approach that gives good results and causes the boiler model to respond as one would expect an operating boiler to respond. The results are measurable, repeatable and can be correlated to actual operating tilt position.

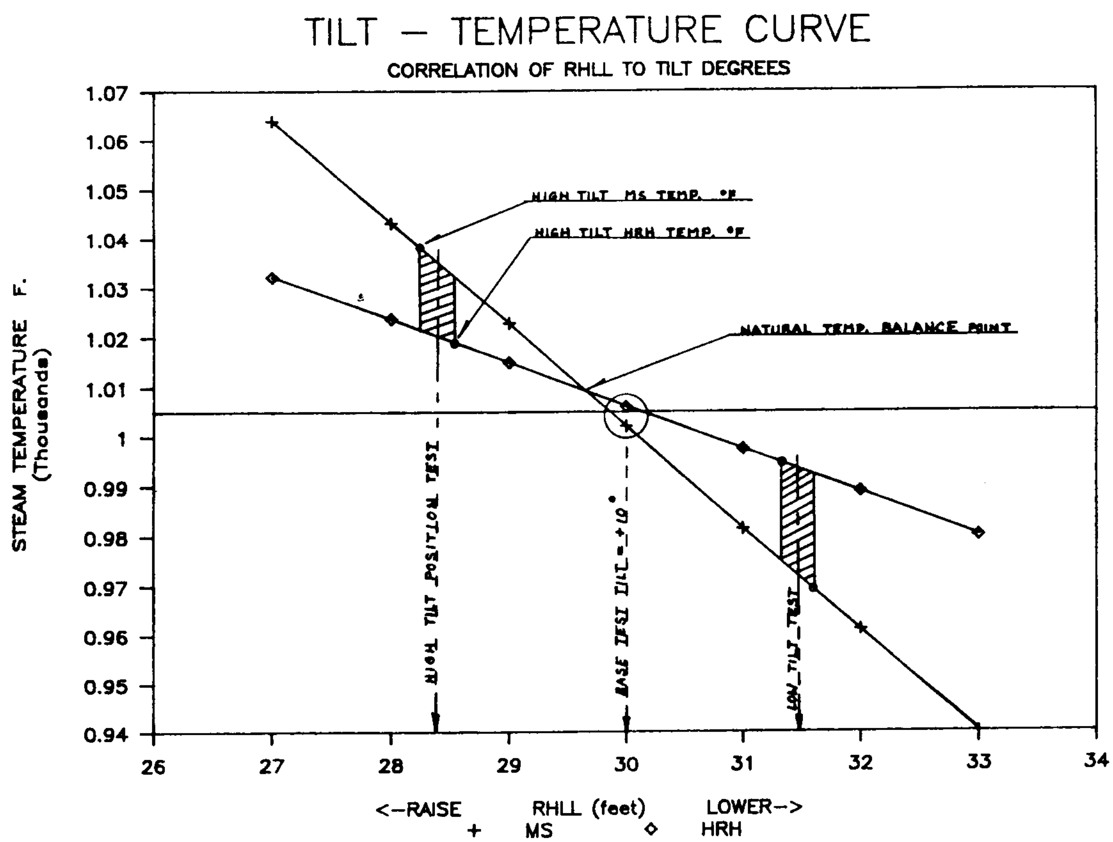
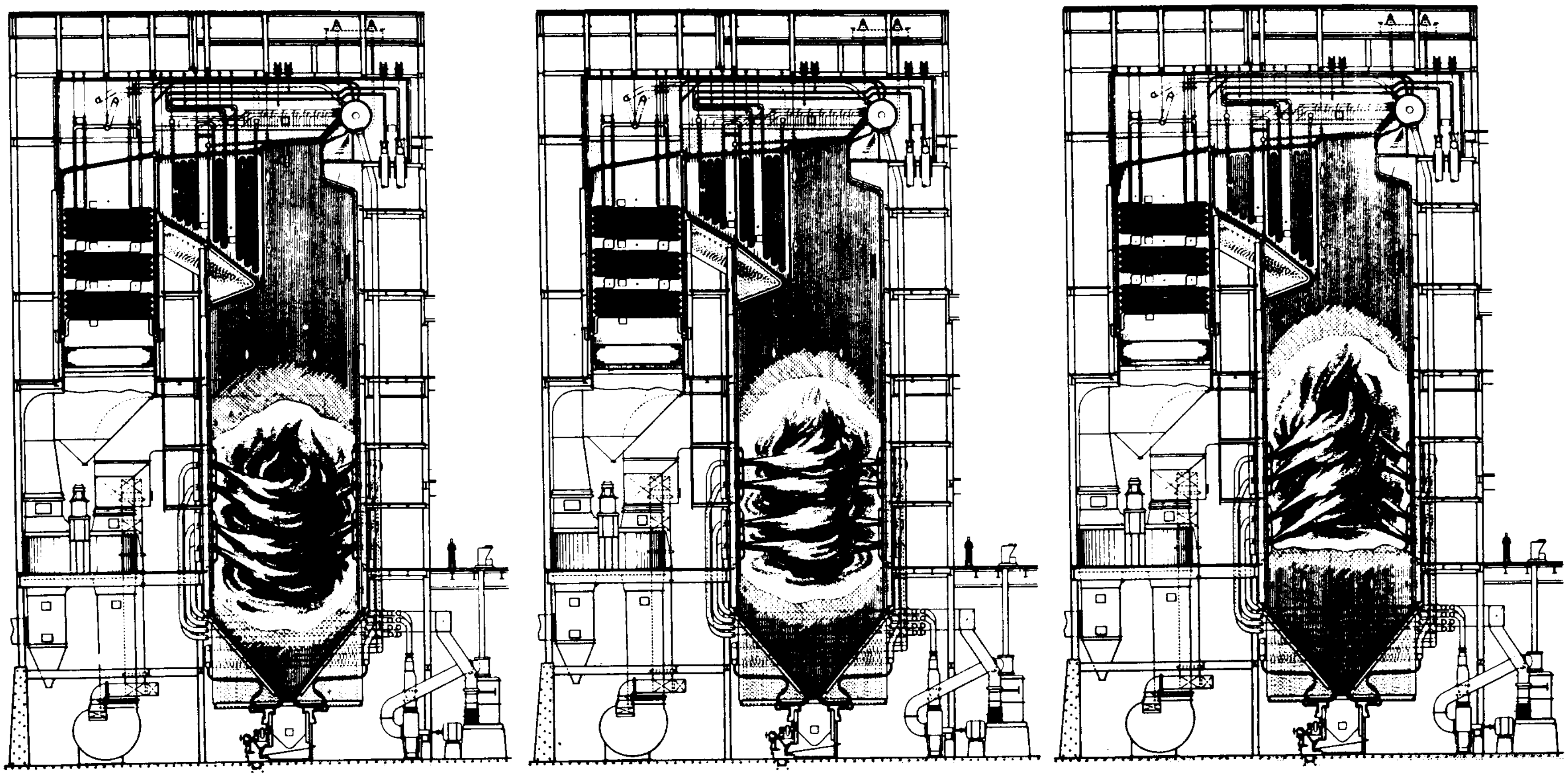
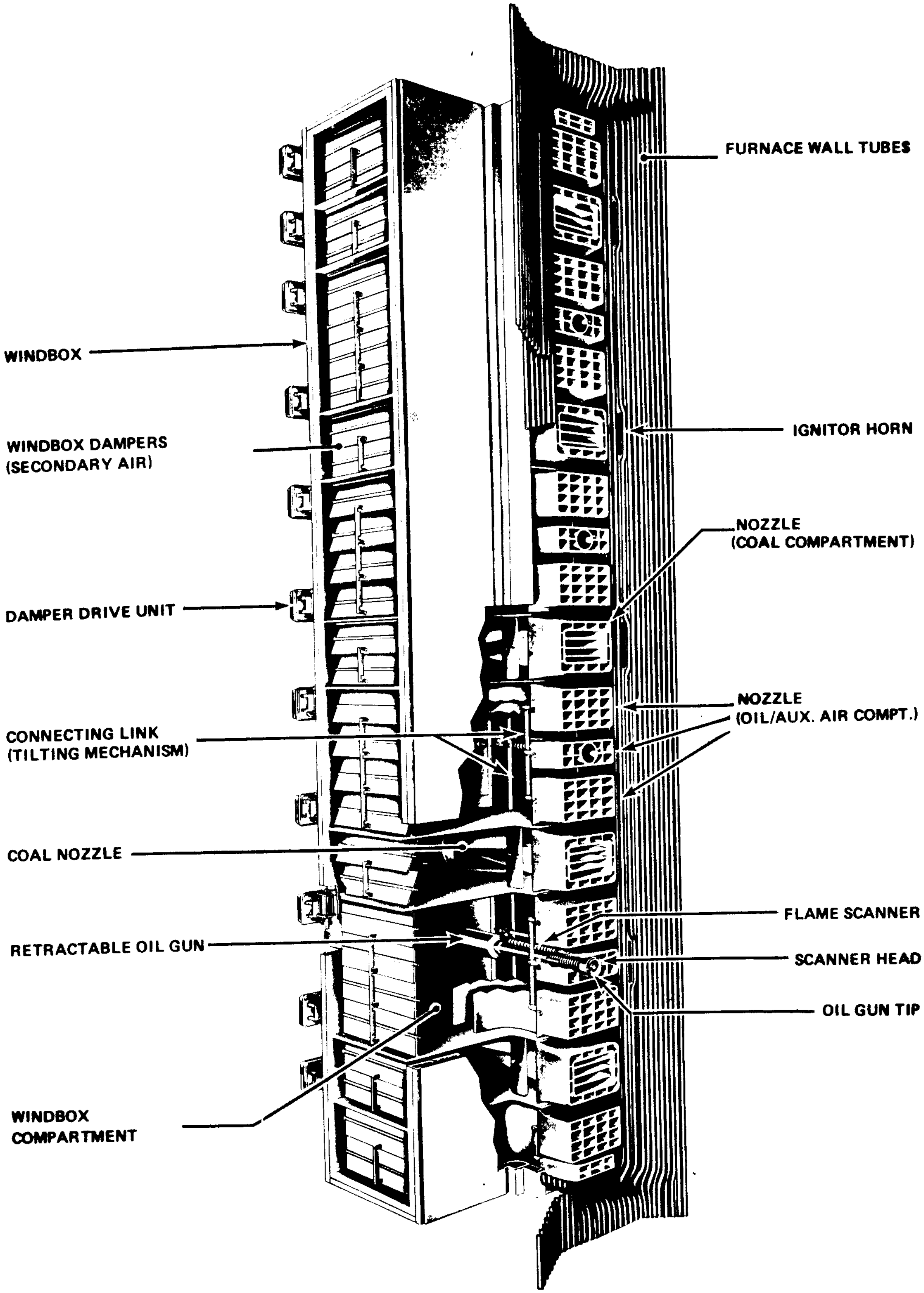


figure 2



Three views of a tangentially fired furnace showing nozzle tilts 30 degrees downward, horizontal and 30 degrees upward.



CUTAWAY VIEW

TYPICAL WINDBOX ASSEMBLY

C-E TILTING TANGENTIAL FIRING SYSTEM