69th IEA-FBC Technical Meeting, Aix-en-Provence, September 2014

FEATURES OF DEVELOPMENT OF BFB-CFB COMBUSTION

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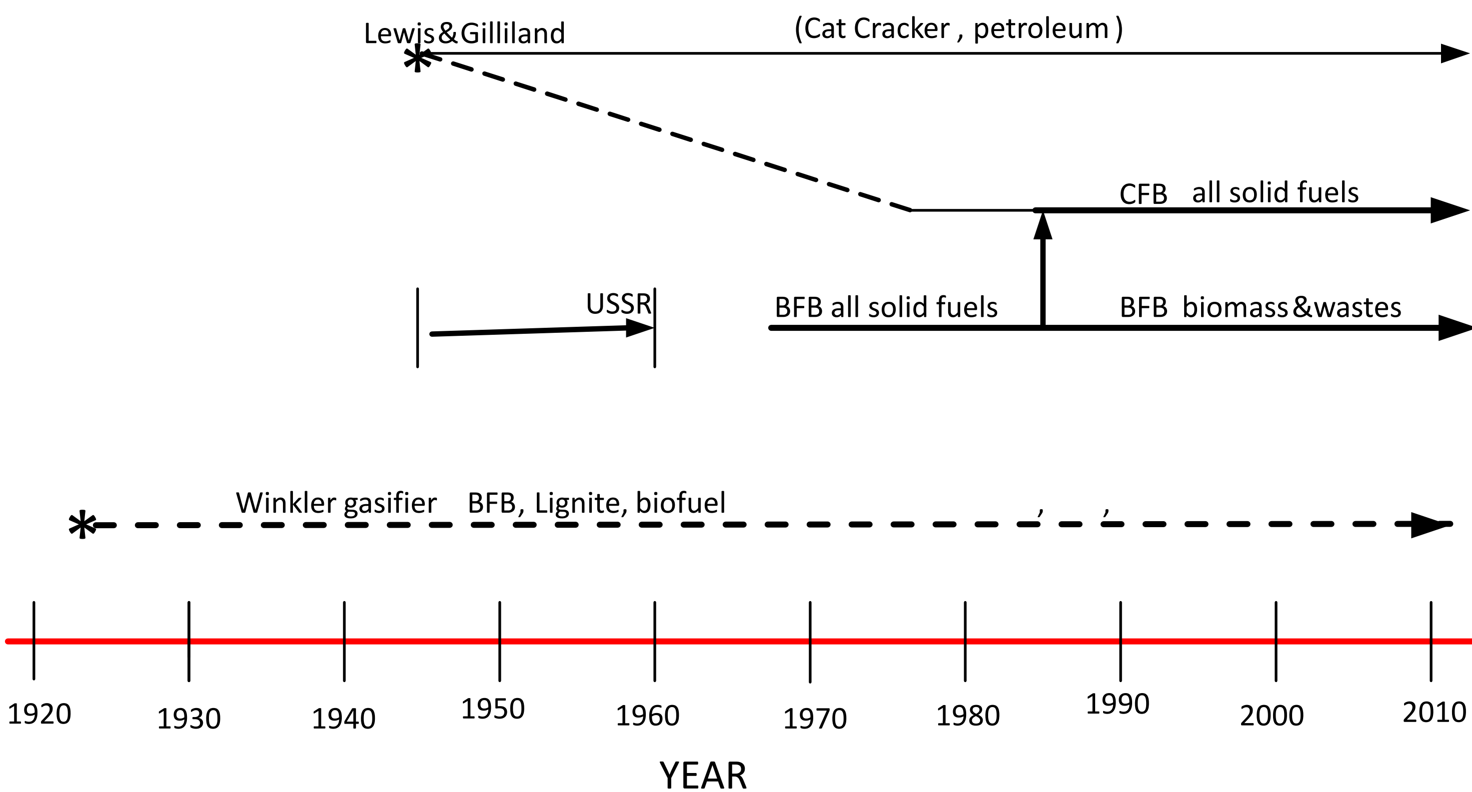
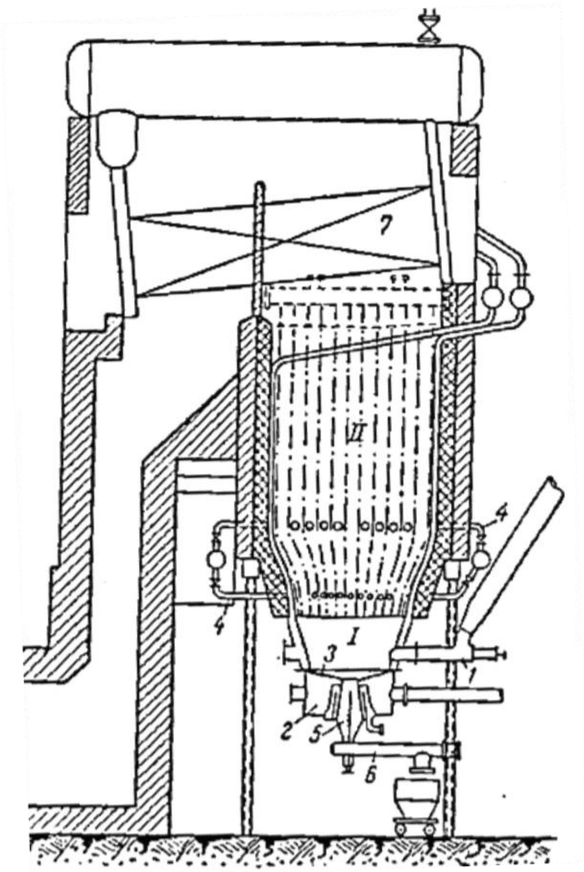
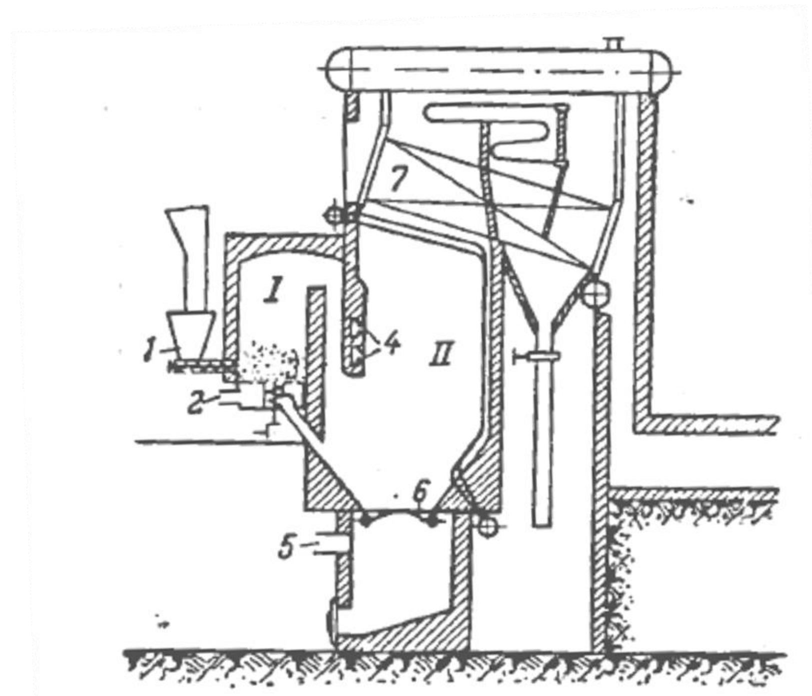
BFB-CFB FUEL CONVERSION HISTORY



SOVIET DEVELOPMENT at Moscow Energy Institute 1945-

From HA Cemenenko, LH Cidelkovski, ”Particularities and experiences from the application of fluidized bed”, Teploenergetika No 3, 1954

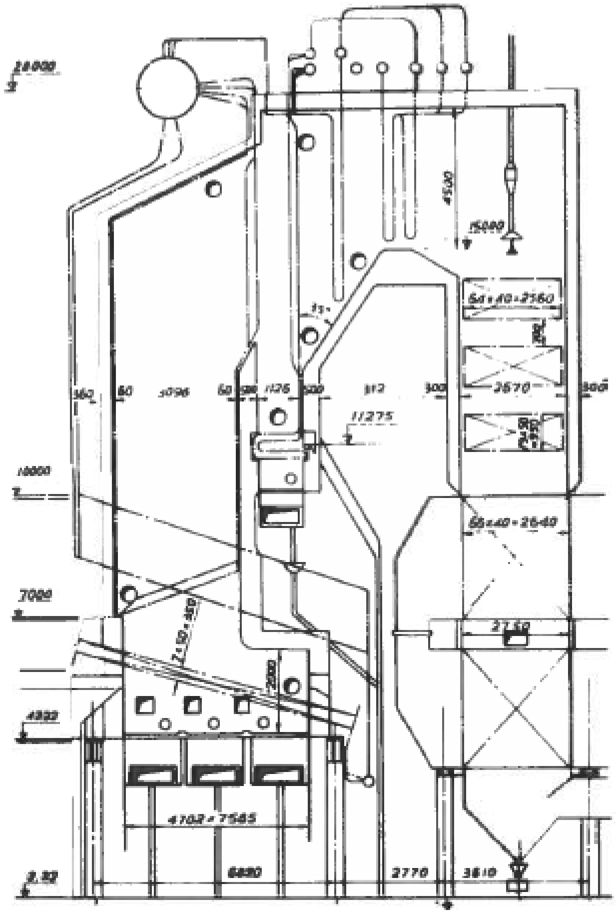




иг. 2. Компоновка

To burn fine residual particles of low-reactive fuels.
No cooling tubes in these figures!

CHINESE DEVELOPMENT



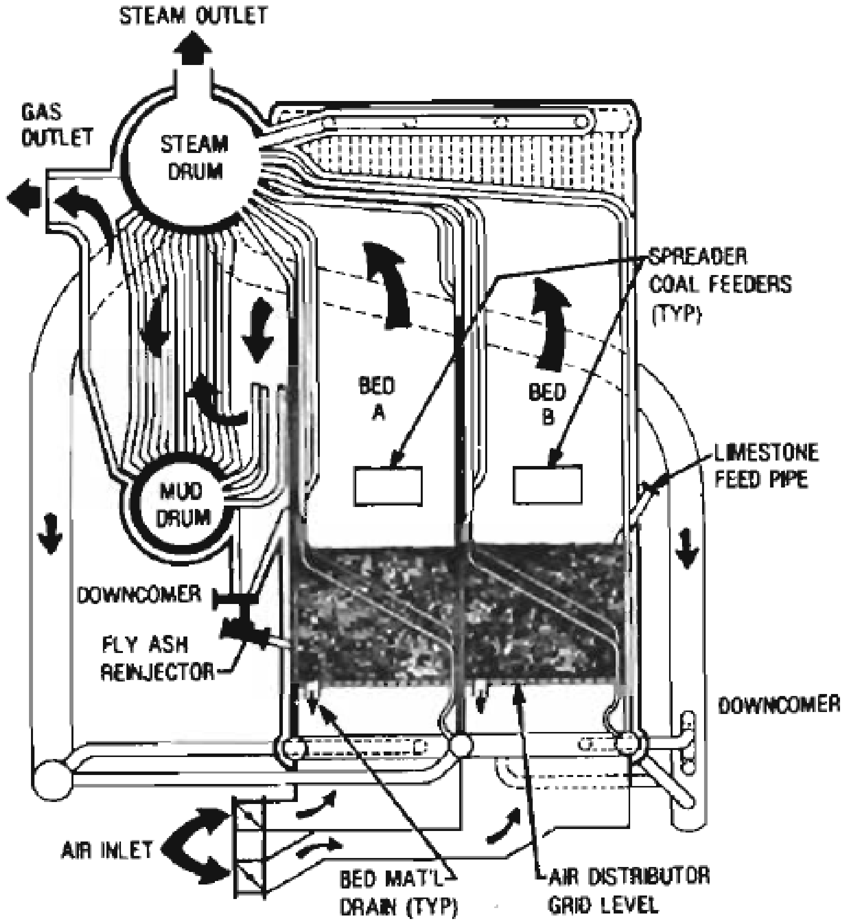
Starting at Tsinghua University 1969 with a 14 t/h boiler.

1980 there were over 2000 FBC boilers in China

The figure shows a 130 t/h power boiler from 1980

Zhang XuYi Proc 6th Int. Cong. On FBC US DoE, 1980.

EUROPEAN- NORTH AMERICAN DEVELOPMENT OF BFB 1970-1985



One of the last boilers in this period: Georgetown FBC 50 t/h boiler, 1980 (FOSTER WHEELER)

CONCLUSIONS FROM THE EARLY DEVELOPMENT

BFB was not further used for coal combustion from the 1980s because of

1. erosion on in-bed heat transfer tubes
2. unfavourable sulphur capture and combustion efficiency.
3. unfavourable scale-up properties

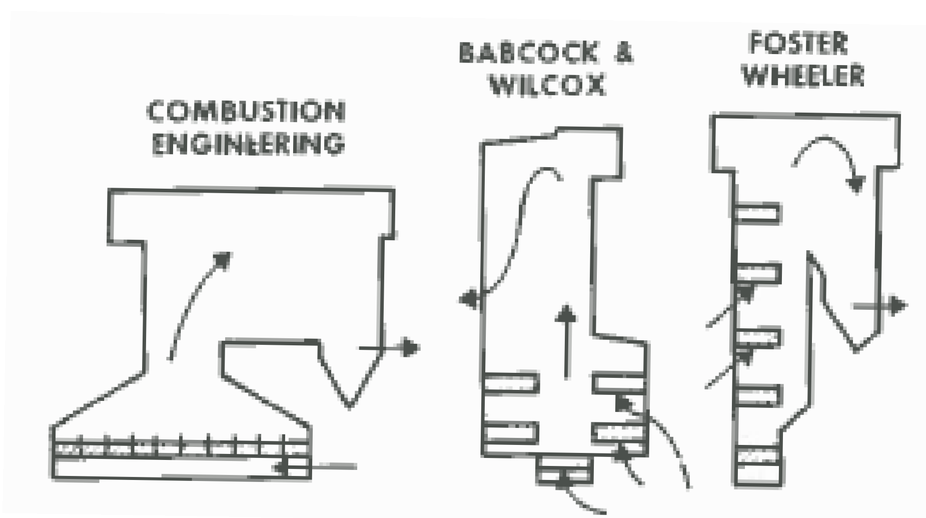
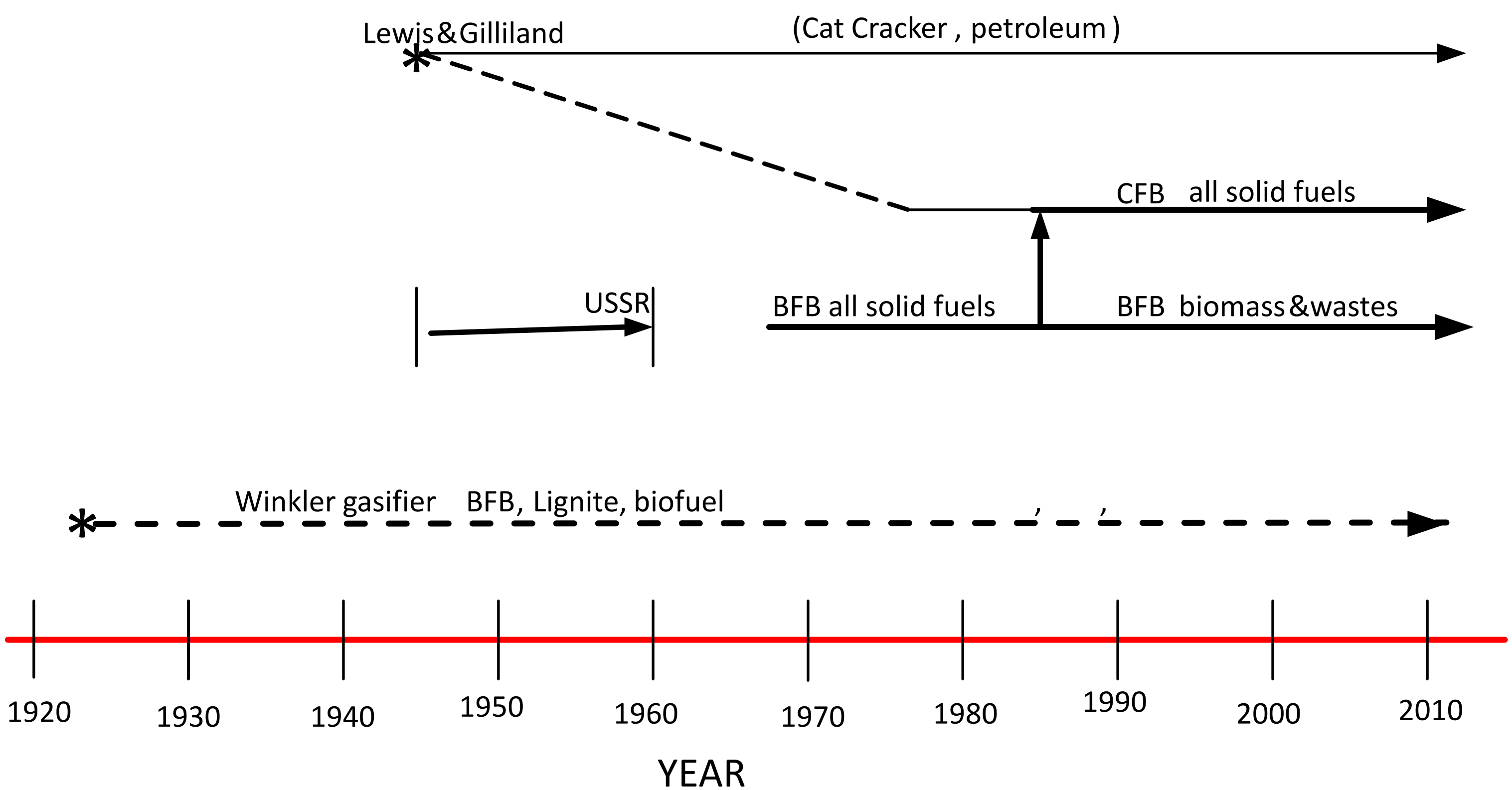


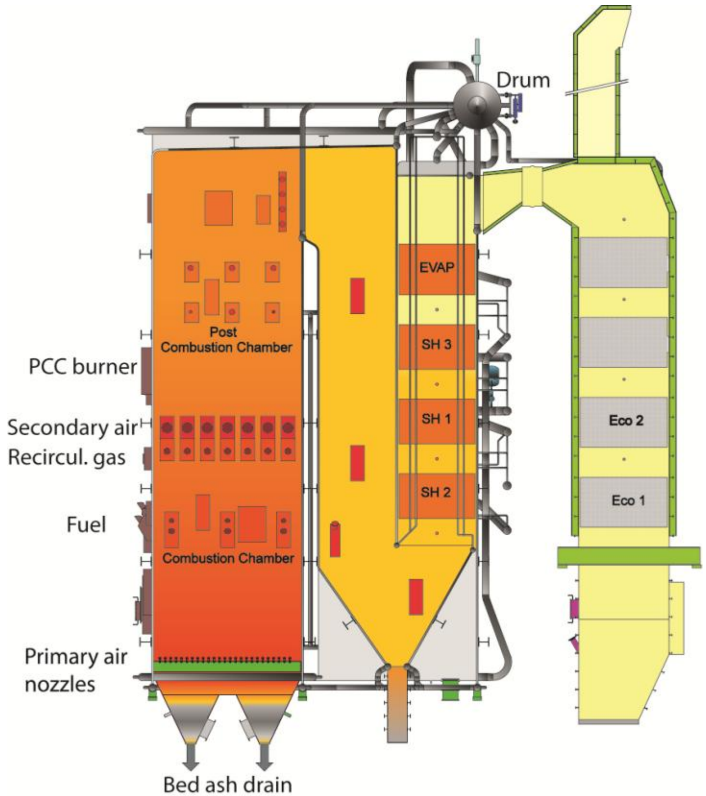
Figure from B. Broadfield, P.F. Lipari, R.S. Slone, Engineering studies of atmospheric FBC electric power plants in the USA, VDI Berichte Nr 322, 1978.

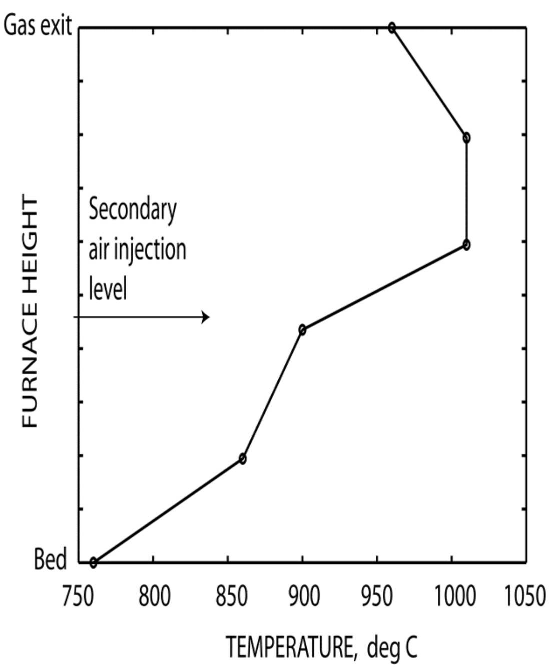
BFB-CFB FUEL CONVERSION HISTORY



BFB BOILER FOR BIOMASS AND WASTE

Small boilers, no tues in the bed. In the present case an empty pass related to waste combustion. Controlled secondary air supply.

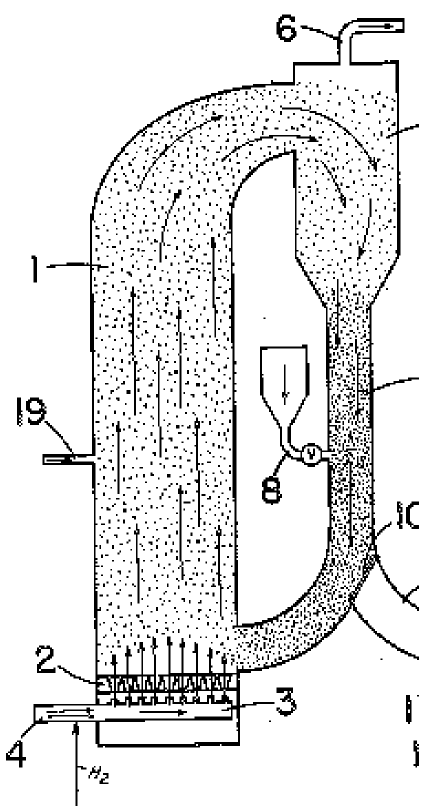




The development of coal-fired boilers went towards CFB

CFB: THE FIRST SUGGESTION

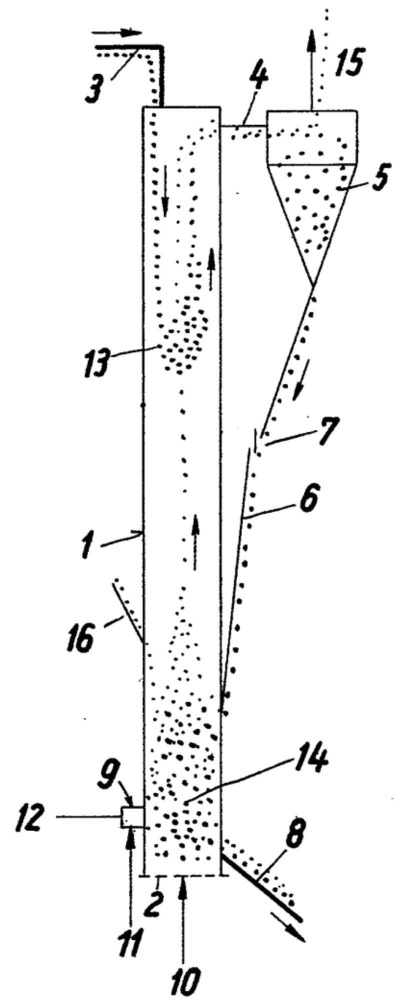
The advantage of high velocity fluidization for chemical reactions was observed by Lewis and Gilliland who issued their patent 1940-50.



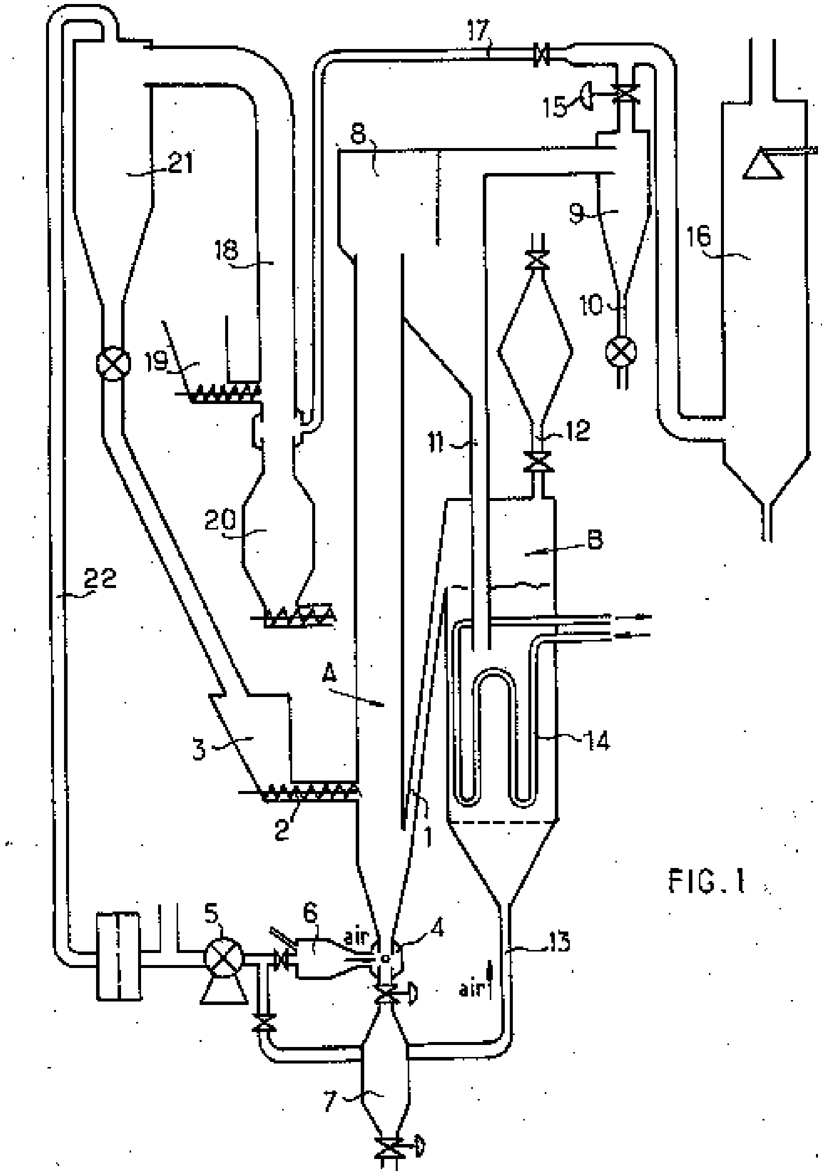
Lewis 1941-44 was the first to propose a CFB reactor "Reaction between solids and gases"

Lewis, W.K., (Standard Oil Dev.Co), "Reaction between solids and gases", *US Patent 2,343,780*, (Patented March, 1944, application August 1941).

CALCINIEREN VON TONERDEHYDRAT
F. Schytil, Metallgesellschaft 1960-63, DAS 1146041

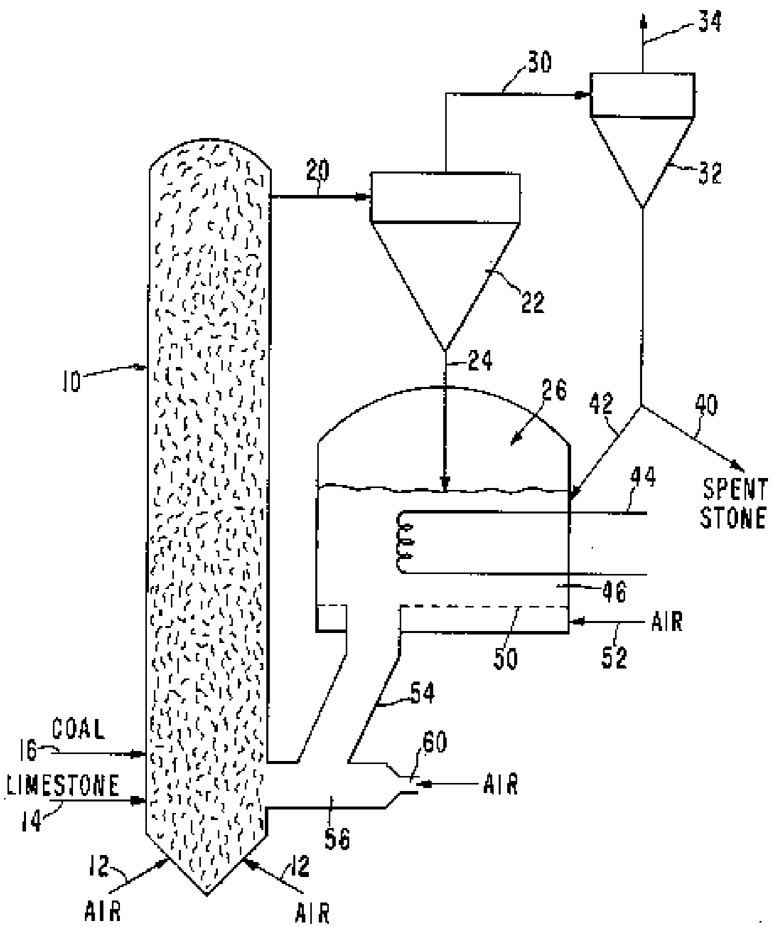


FIRST COMBUSTION CFB

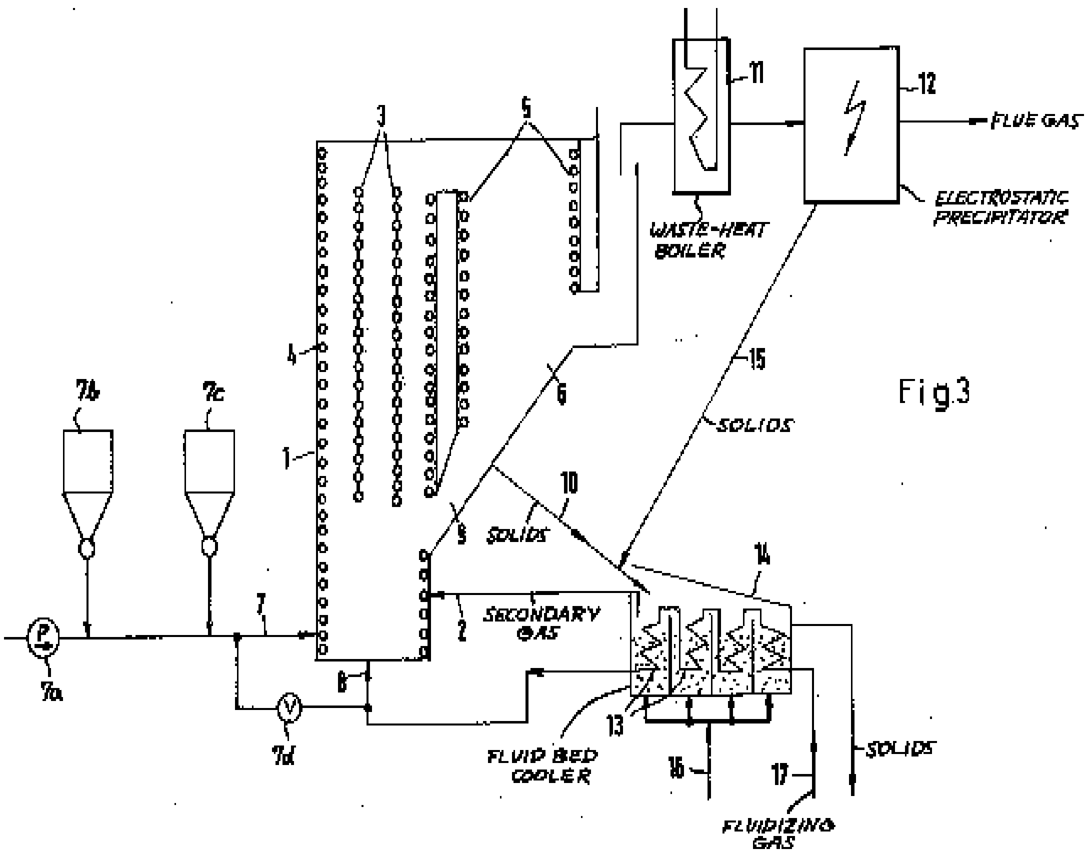


Stahl, Becuwe 1972-74 Rhone Progil, France: Procedure for combustion of industrial or household wastes

A FAST AND SLOW BED BOILER, J. Yerushalmi, S.Erlich, EPRI, (March) 1977-78, US4103646

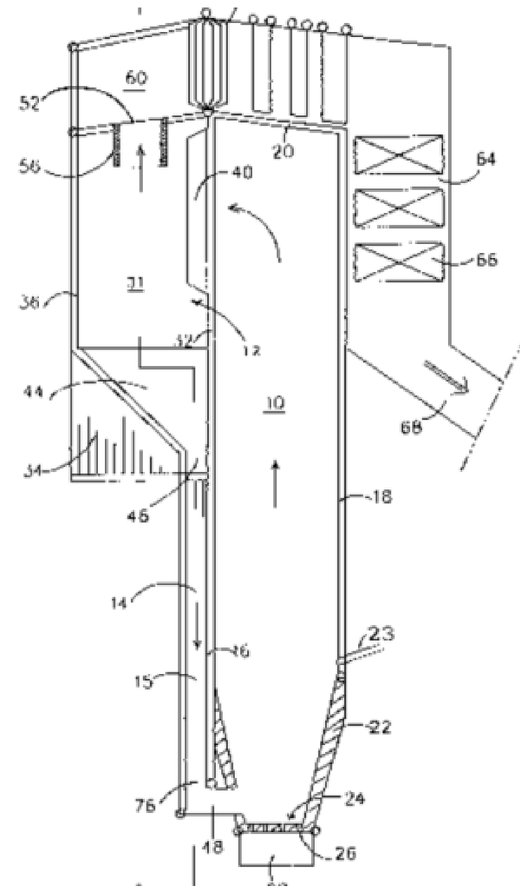


PROCESS FOR BURNING CARBONACEOUS MATERIALS
Collin, Flink, Reh, Metallgesellschaft, (May) 1977-79, US 4111158, US 4165717

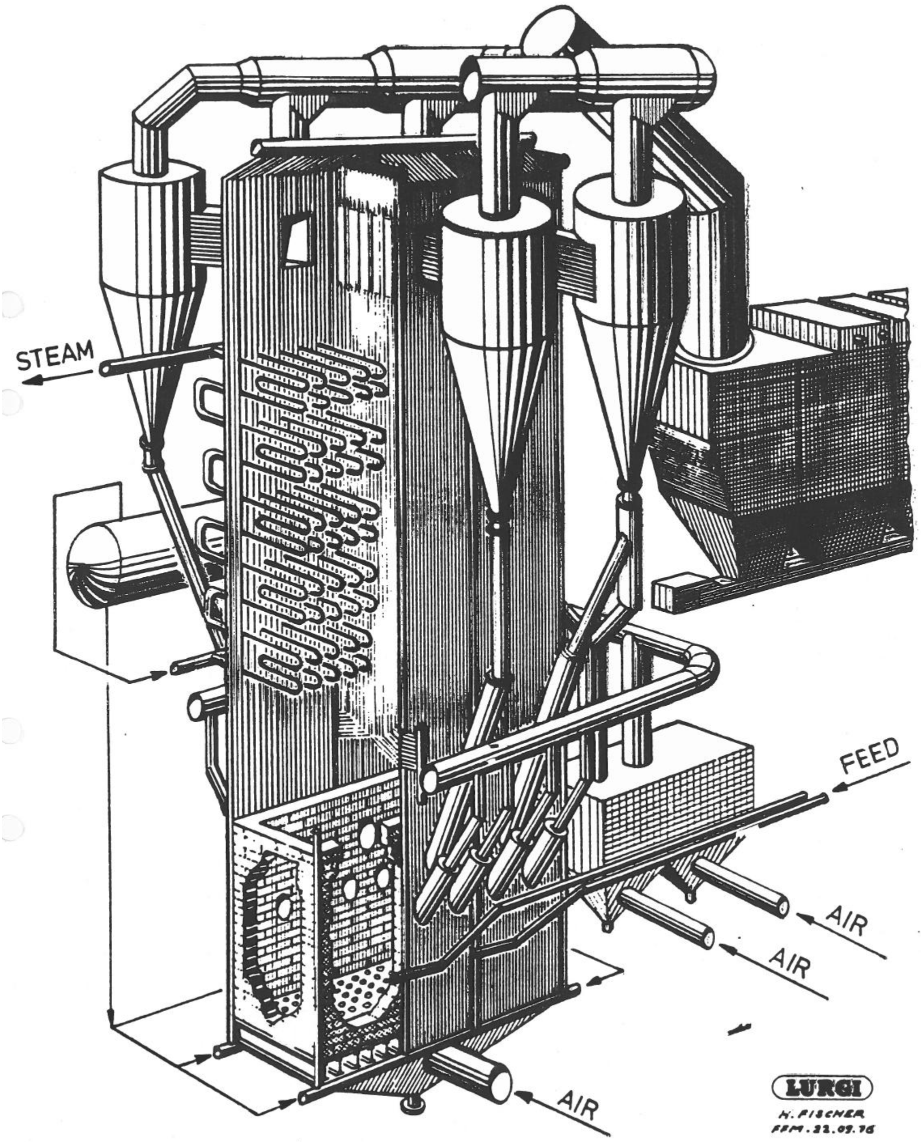


- Primary-secondary air
- Suspension density above secondary air 10-40 kg/m^3.
- Gas velocity 5-15 m/s
- Continous solids density gradient from the bottom of the fluidized bedto the top of the reactor.
- Particle size 30-250 µm

THE "SQUARE" CYCLONE: Centrifugal separator, T Hyppänen and R Kuivalainen, A. Ahlström Co. Finland US 5281398, 1992-94



THE ORIGINAL LURGI CFB COMBUSTOR

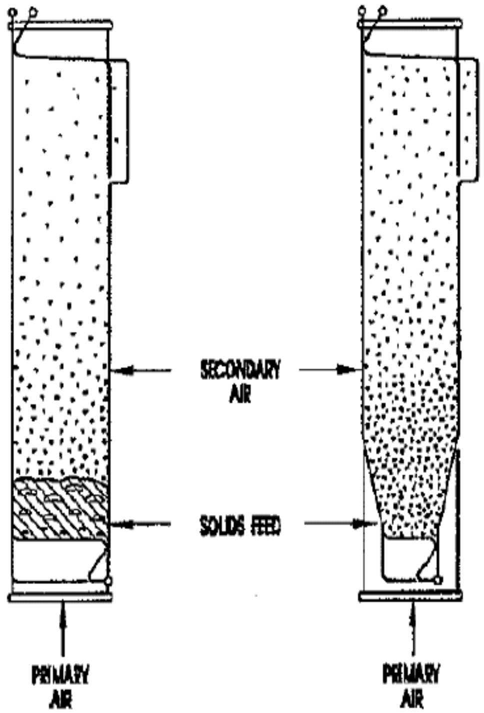


Proposed 1976 for combustion of oil shale in Sweden and South Africa.

L.Plass, G Daradimos, H Beisswenger, Deveopment of the circulating athmospheric fluidized bed to an environment –conservong combustion technology, VGB Kraftwerkstechnologie 67(5), 399-405 (1987).

THE CFB PROCESS ACCORDING TO FOSTER WHEELER <1995

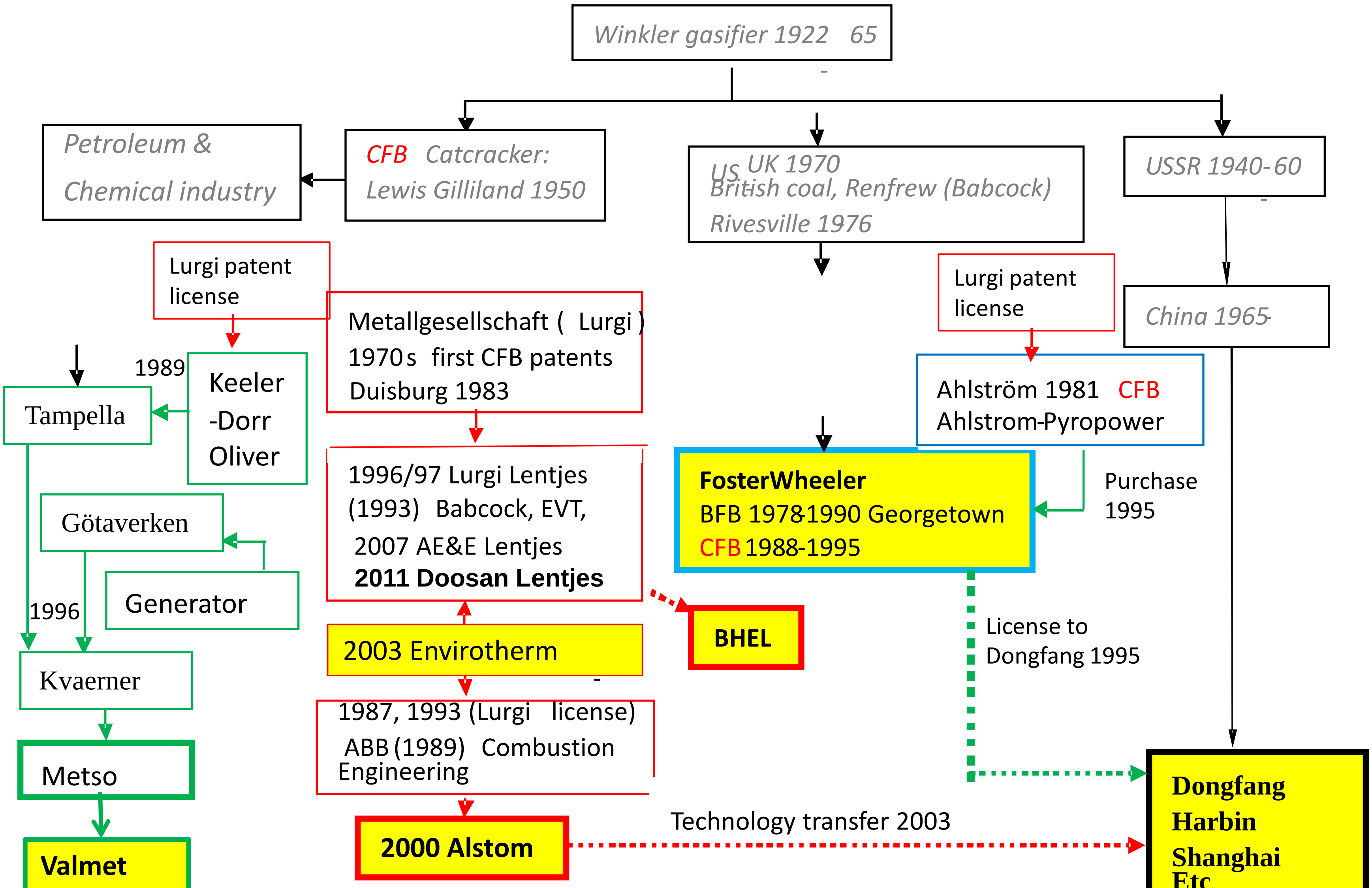
I. Abdulally et al., The 5th Int. Power Generation Exhibition & Conf., Orlando Fl, 1992.



"The Foster Wheeler process is characterized by the presence of a pronounced bed in the bottom few feet of the furnace and a relatively solids-lean freeboard above it.

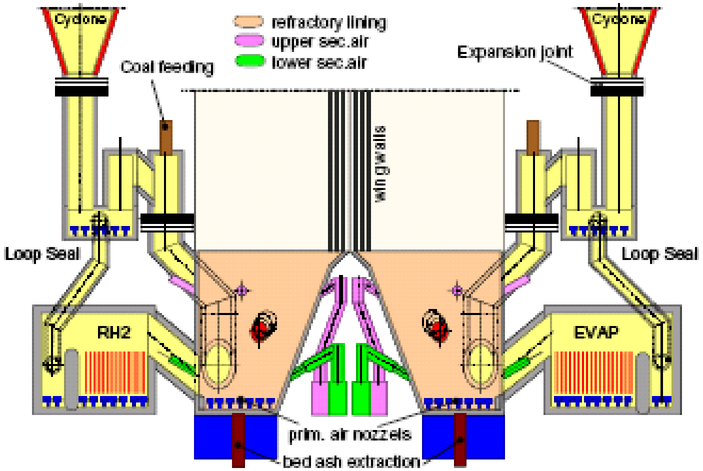
An alternative process, i.e., fast fluidized or highly expanded bed, is characterized by having the solids spread over a substantial height of the furnace with the absence of a pronounced bed at the bottom of the furnace ....."

CFB MANUFACTURERS AND THEIR RELATIONS

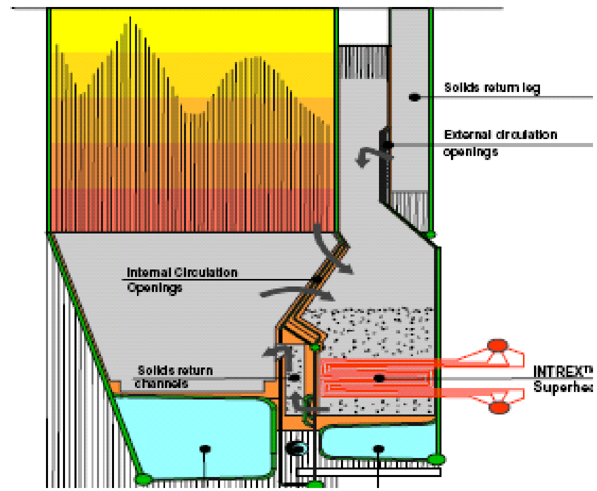


The designs are approaching each other. There remains some individual features such as seen below:

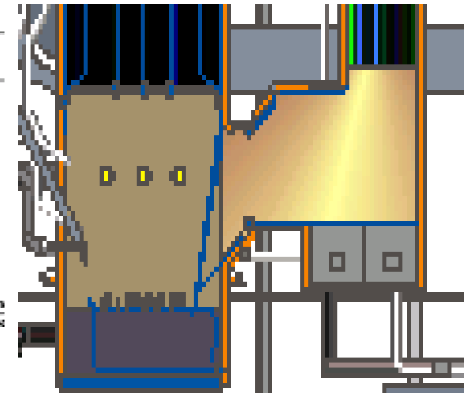
Bottom parts with external heat exchangers



Alstom



Foster Wheeler

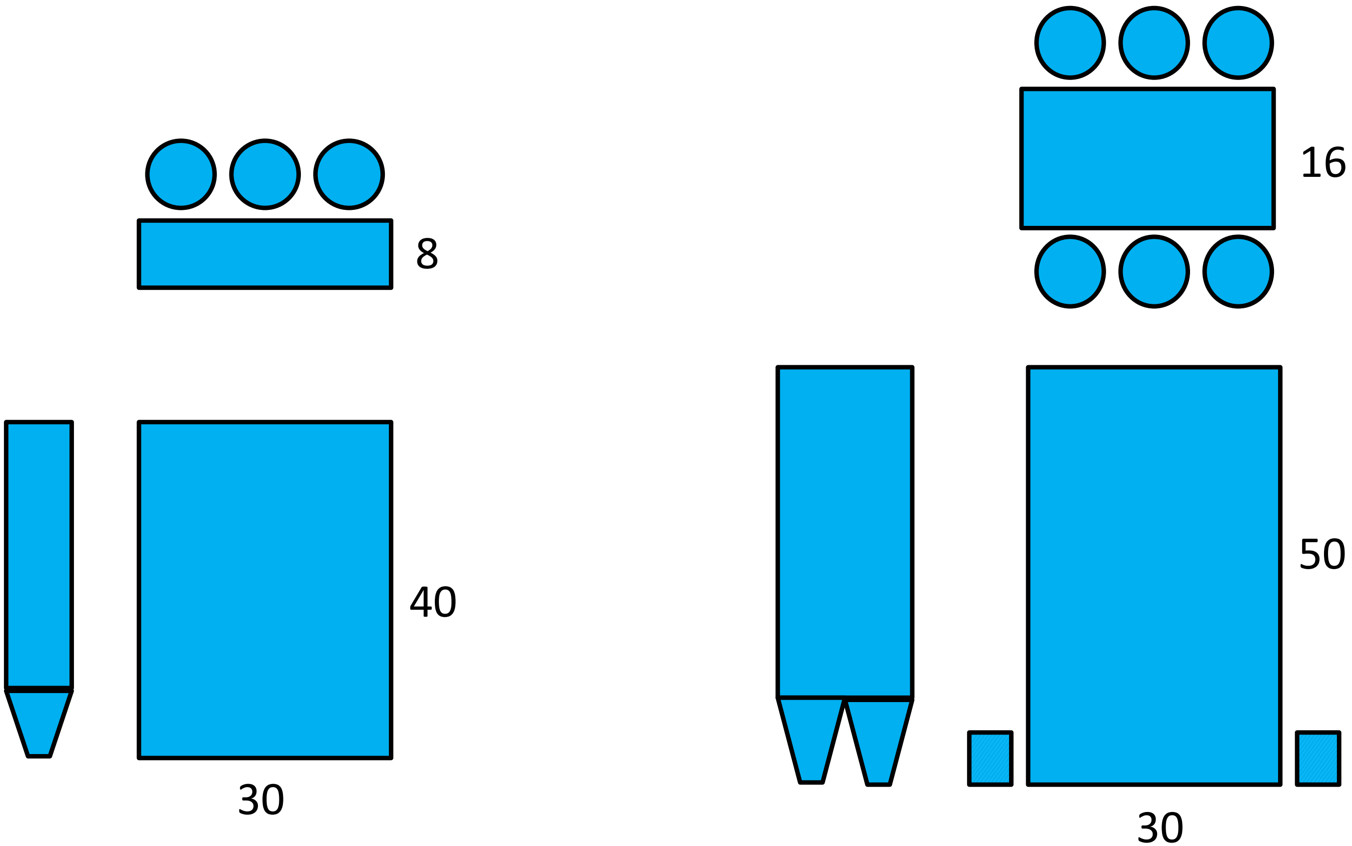


Valmet (previously Metso)

RECENT INTEREST

- Scale up
- Oxy-fuel, high oxygen concentration
- Other CO_2 capture methods: Calcium looping, Chemical looping

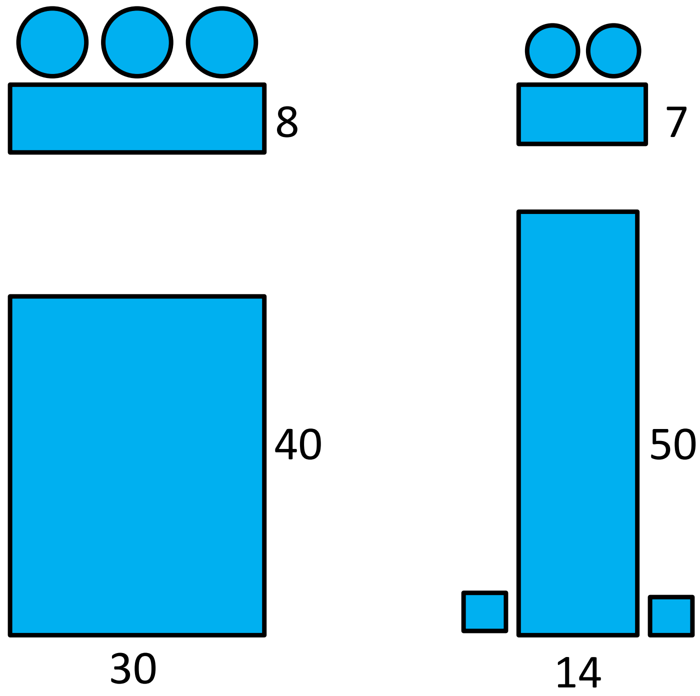
SCALE-UP OF A CFB BOILER FROM 300 TO 600 MW_e
Dimensions in m



300 MW

600 MW

AN OXY-FUEL CFB BOILER @ 60% O_2



300 MW CFB
Air vs oxy (60%)
Dimensions in m

FINAL WORDS

The dominant patents have expired.

The various designs prevailing have converged into a few groups

1) Foster Wheeler with its compact design forms a unique trend by itself.
2) Envirotherm administers licences to various companies based on the Lurgi technology. The largest manufacturer whose design originated from Lurgi is Alstom.
3) The general design with hot or cooled cyclones, internal wing-wall heat transfer surfaces, and possibly a heat exchanger in the loop seal, is followed by a great number of manufacturers like the Jacksonville type of Foster Wheeler’s design (especially USA), Alstom without external heat exchangers, Valmet etc.
4) The most important development and application at present takes place in Asia, especially in China.