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1st Issue

FLARE

The Anti-Pollutant Smokeless Flare

FLAREGAS

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Flaregas Engineering Limited

Head Office and Works:
Bentinck House
Bentinck Road
West Drayton
Middlesex
England UB7 7SJ

Telephone:
West Drayton 44031
Telegrams:
Jonproc West Drayton
Telex:
23923

FLAREGAS CORPORATION
137 S. Middletown Road
Nanuet, New York 10754
Phone: 914-623-4220

Flaregas equipment is patented or has patent applied for in principal countries including Japan, Great Britain, West Germany, U S A, Italy

The trade names :-

'Flaregas' 'Flarex' 'Tribolite'

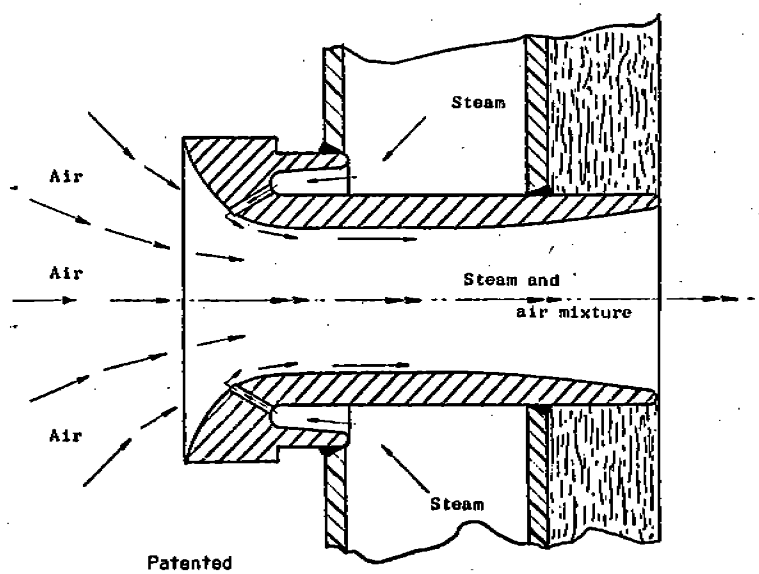
'Triboliter' 'Flarejector' are

registered

THE FLAREGAS ANTI-POLLUTANT SMOKELESS FLARE TIP

The Flaregas 'FS' anti-pollutant Flare Tip is the result of exhaustive product research and experiments carried out both at I C I Wilton and on our own research plant.

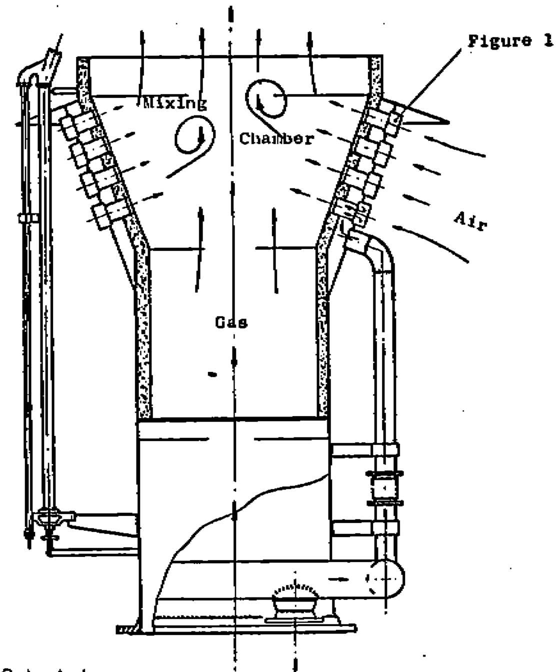
The design is based on the concept of thorough mixing of gas, air and steam prior to combustion, which is carried out in the unique Flaregas mixing chamber. Steam is used to inspirate air through units termed 'Flarejectors'. This advanced technological design gives maximum inspirating efficiency with minimum noise.



Patented

FIG 1

The steam is evenly distributed to the 'Flarejectors' by the use of a steam chest built around the upper portion of the Tip. As the steam flows through the chest into each 'Flarejector' and finally into the mixing chamber it acts as a cooling medium and in this manner prolongs the working life of the unit. The mixing chamber itself is lined on the inside with a refractory insulant to protect the Tip in the event of burning back.



Patented

FIG 2

The 'FS' Tip is engineered to a quality specification which ensures a high standard of manufacture and operation. Those parts exposed to flame contact are fabricated in high quality heat resistant stainless steel. Castings and steam chest are manufactured in stainless steel stabilised with Niobium and the chest is pressure tested to 150 psig. Inspection methods employed during fabrication include radiography, ultrasonic testing and dye penetrant examination, as required.

Research into pollution-free flaring and development of the 'FS' Tip is continuous and the Flaregas engineering department is willing to advise on any disposal problems. Expert chemists and consultant engineers are available to advise on original or unusual problems and facilities are available for testing samples of effluent for flammabality or pollutant production.

SMOKELESS FLARING AND SMOKE SUPPRESSION

The simplest approach to smokeless combustion is to consider the fundamental principles involved in the chemical reaction between hydrocarbon and air. Oxygen in the air combines preferentially with the hydrogen atoms attached to the carbon chain of the hydrocarbon, leaving the carbon to be combusted as a type of secondary reaction in the same manner as branches of a tree will be consumed before fire attacks the trunk.

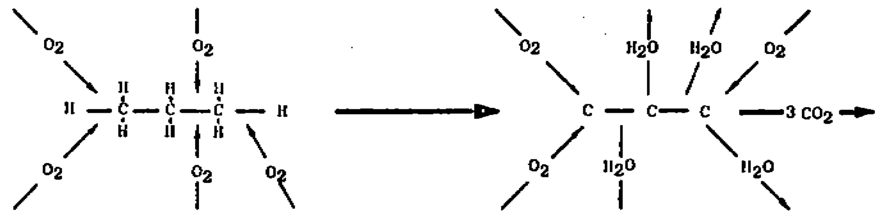


FIG 3

A long chain or one having many branches may be attacked at several points and break into smaller chains before the whole is consumed.

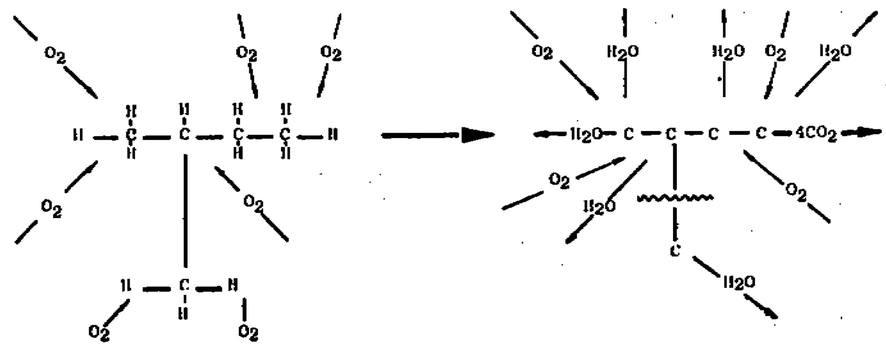


FIG 4

If the carbon chain splits due to the high temperature brought about by the $H_2 + O$ combustion reaction, then the probability of elemental carbon production is increased and this carbon, unless combusted by oxygen, appears as smoke. The quantity of carbon formed depends upon the molecular structure of the hydrocarbon. A long paraffinic chain will split more easily than a short one; an olefinic chain with unsaturated bonds is even more susceptible to temperature and the aromatic ring combines both disadvantages of unsaturated bonding and long chains to produce the highest percentage of free carbon.

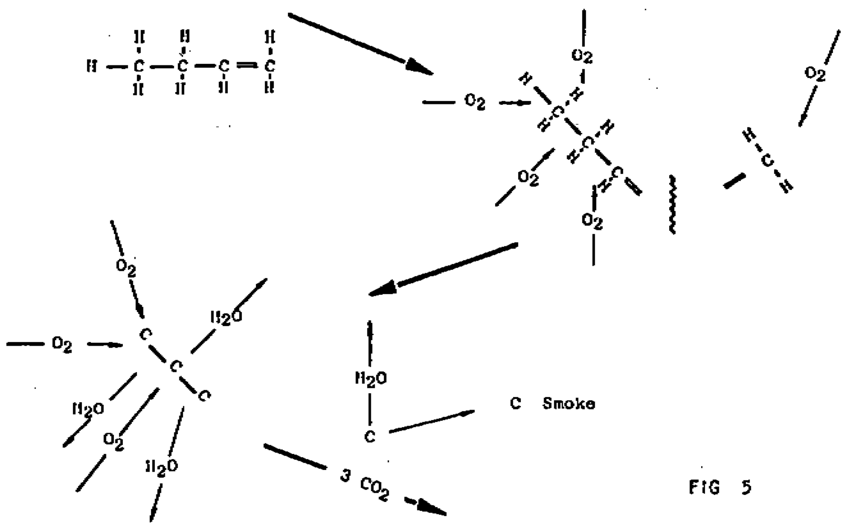


FIG 5

Whatever the quantity of free carbon produced it will still be converted to carbon dioxide and does not produce smoke provided that oxygen is available. This requires adequate air/gas mixing and as oxygen represents only one fifth of the air used, the bulk of the nitrogen acts as a retardant to the chemical reaction and, therefore, to the combustion temperature. Thus a pre-mix gas burner will not produce smoke in a hot furnace atmosphere. Flaring of hydrocarbon gas as a raw gas flame does not allow for adequate air/gas mixing so that the carbon appears as thick smoke. A raw gas flame can be compared with a sausage, whereby the skin of flame, representing the zone of chemical reaction, prevents air reaching the 'meat', i e the gas inside this envelope. Heat radiated from this envelope penetrates into the gas and excites the molecules to the level of disintegration. [redacted] A steam and air mixture as created by the 'Flarejector' device in the 'FS' Flare Tip ameliorates the situation by reducing the amount of unconverted hydrocarbon. The steam/air mixture is introduced into the gas prior to ignition and the energy of this stream is utilised efficiently to produce a high degree of mixing so that the proportion of unconverted gas is reduced to a minimum.

Operation of the 'FS' Tip on a wide range of gases has provided a number of practical steam/gas rates for smokeless combustion. It has been shown by small and large scale tests and by operational results that the 'Flarejector' reaches its optimum efficiency of air entrainment when operating at a steam pressure of 50 psig. At this pressure a 'Flarejector' ejects into the flare a volume of air approximately 16 times the volume of the steam at injection conditions. By selecting a maximum design pressure of 80 - 100 psig, it is possible to keep the 'Flarejector' within the effective operating range throughout the turn down range.

Test and operational data obtained has been sufficient to enable the drafting of a proposal to permit steam rate sizing. This proposal is shown in Figure 6. The curves are designed to be used to indicate practical operating rates and are based on definite site data. Specific data has been obtained on the more usual hydrocarbon gases with molecular weights up to approximately 60. The curves beyond this molecular weight are produced by extrapolation on the basis of equal increments in steam requirement with increasing numbers of carbon atoms.

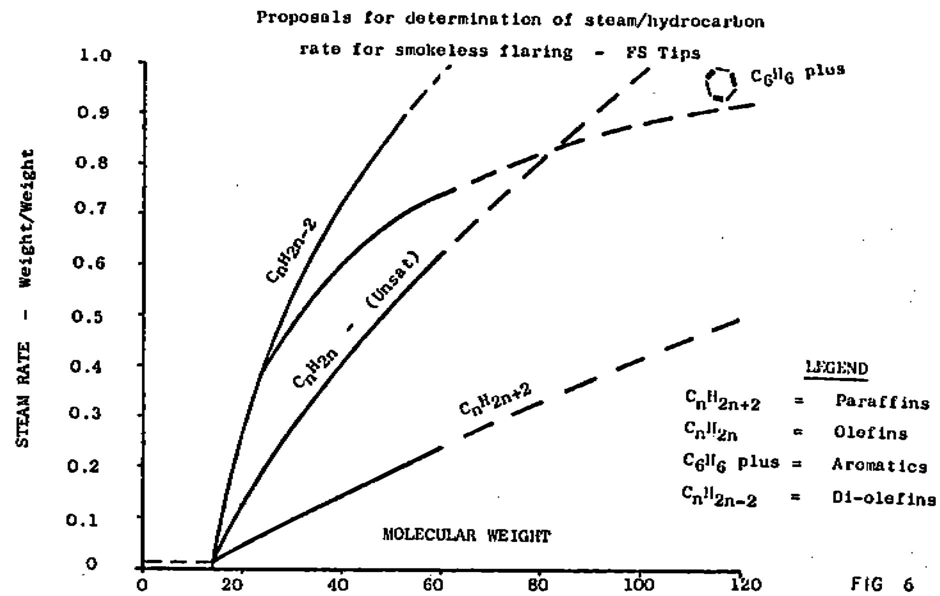


FIG 6

In general, the steam requirement of the 'FS' Flare Tip is less than that of other designs and will improve on the figure deduced from the curves when operating at maximum efficiency. As a specific example of this, it is possible to cite Butadiene on which controlled tests have been made under the auspices of I C I Wilton in England. A Steam/Butadiene rate in excess of 1 wt/wt is normal in plant employing external steam injection Flare Tips, whereas 'FS' tests produced ratios in the range 0.67 wt/wt to 1.05 max with most results around 0.75. The proposal submits a figure of 0.9 for this particular gas to ensure sufficient availability of steam with a margin of over capacity. Similarly, a propylene test estimated by observers as requiring 0.6 wt/wt proved satisfactory in the range 0. 315 to 0.47 with mean readings around 0.4 wt/wt.

Example :-

Predict the steam/hydrocarbon rate for a flare gas having the composition -

CH_4	2% weight
C_2H_4	4% weight
C_2H_6	18% weight
C_3H_6	67% weight
C_3H_8	5% weight
C_4H_8	3% weight
C_5+	1% weight

From chart approximate steam rates (all figures rounded off for convenience) -

CH_4	0.01	x	0.02		
C_2H_4	0.26	x	0.04	=	0.01
C_2H_6	0.10	x	0.18	=	0.02
C_3H_6	0.44	x	0.67	=	0.30
C_3H_8	0.17	x	0.05	=	0.01
C_4H_8	0.58	x	0.03	=	0.02
C_5+	say 0.6	x	0.01	=	0.01
Final steam rate					0.37 wt/wt

Earlier testing on steam rates have linked smoke production to molecular weight (of mixed refinery gases) or to the degree of unsaturation, but has not apparently combined the two. Consequently, comparison with published results is difficult. However, it would certainly appear from site and published data that steam rates for smokeless operation using centre steam injection are invariably in the range 1 - 1.5 wt/wt and that external steam injection is frequently 30% in excess of 'FS' results at maximum efficiency and some 10 - 15% in excess of figures predicted by the chart.

NOISE REDUCTION

Extensive noise tests on the 'FS' Tip have shown that the Flaregas method of injecting steam into the flare gas stream is substantially quieter than other methods involving centre steam injection inside the Flare Tip or external injection from a manifold and steam heads around the Flare Tip.

From these tests it has been possible to project noise production from the various types of Flare Tip and Figure 7 shows comparative noise readings for Flare Tips operating at a nominal 1 ton/hr steam rate. The noise levels curves are based on actual tests and field data with steam pressure around 50 psig. The curves are corrected to 10 metres from source in order to show a comparison with the ISO 85 criterion.

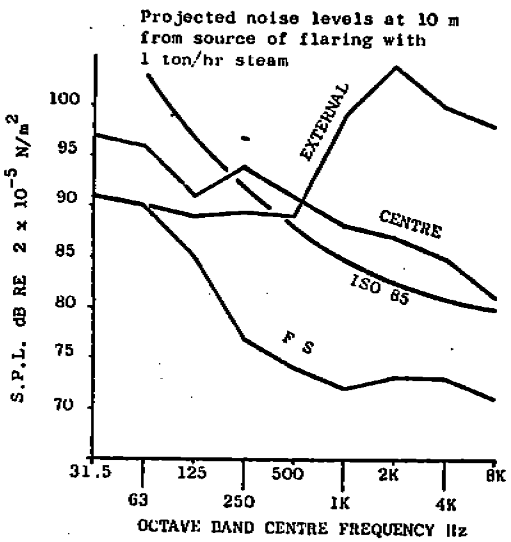


FIG 7

As may be seen the 'FS' Tip shows a significant improvement in the noise level during flaring especially in the higher frequencies which cause greater discomfort physiologically. Consequently, dBA figures are reduced and in general dBA readings are approximately 15 - 20 dB below the overall linear reading of dB for an 'FS' Tip. With external injection, however, linear dB and dBA readings will be almost equal.

Tests on the 'FS' Tip have lead to the formulation of two formulae which enable prediction of noise levels. These formulae are shown together with correction factors in Figure 7.

NOISE LEVELS - 'FS' TIP

SPL dB 1 m from source

31.5 Hz to 500 Hz Octave bands

Basic SPL = 115 + 15.35 $\log_{10}$ (tons of steam/hour)

Octave band corrections :-

31.5 Hz	Basic SPL from formula	- 4dB
63 Hz	" " " "	- 5dB
125 Hz	" " " "	- 10dB
250 Hz	" " " "	- 18dB
500 Hz	" " " "	- 21dB

1K Hz to 16K Hz Octave bands

Basic SPL = 99 + 13.1 $\log_{10}$ (tons of steam/hour)

Octave band corrections :-

1K Hz	Basic SPL from formula	- 7dB
2K Hz	" " " "	- 6dB
4K Hz	" " " "	- 6dB
8K Hz	" " " "	- 8dB
16K Hz	" " " "	- 10dB

Example : -

'FS' 24 Flare Tip burning 4.6 tons/hour of propylene/propane mixture at a steam/hydrocarbon rate of 0.32 wt/wt :-

Steam rate = 4.6 x 0.32 = 1.47 tons/hr

$\log_{10}$ 1.47 = 0.1675

Centre band frequencies: 31.5 Hz to 500 Hz

Basic SPL = 115 + 15.35 x 0.1675 = 117.6 dB

31.5 Hz	- 113.6 dB
63 Hz	- 112.6 dB
125 Hz	- 107.6 dB
250 Hz	- 99.6 dB
500 Hz	- 96.6 dB

Centre band frequencies: 1K Hz to 16K Hz

Basic SPL = 99 + 13.1 x 0.1675 = 101.2 dB

1K Hz	- 94.2 dB
2K Hz	- 95.2 dB
4K Hz	- 95.2 dB
8K Hz	- 93.2 dB
16K Hz	- 91.2 dB

Overall linear reading : 117 dB

'A' weighted reading : 102 dBA

At 45 m from source : -

Overall linear reading : 83 dB

'A' weighted reading : 68 dBA

Distance and atomospheric absorbtion of noise must also be considered in prediction of noise levels and these effects can be determined by reference to Figure 8.

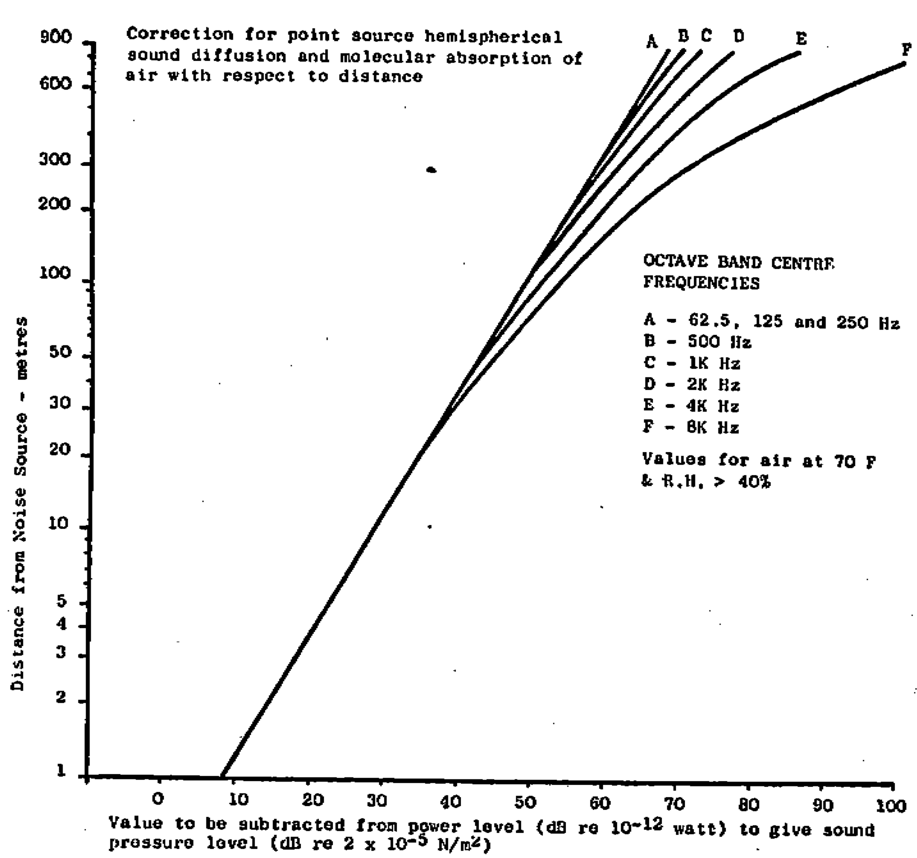


FIG 8

WHAT'S GOING ON

From AUSTRALIA - Our Agents:-

Uniquip Pty Ltd
83 Willoughby Road
Crows Nest
N S W
Australia 2065

report that the first Flaregas Anti-Pollutant Flare Equipment to be built in Australia has been delivered to C S R Chemicals Pty Ltd.

The equipment has been designed for the following conditions:-

Flow Rate (scfm)	Mol Wt	Composition	Temp °F
Maximum 31,700	14.6	CO H_2 CO_2	Ambient
Sustained Emergency 76,000	23	C_2H_4 C_2H_6 C_3H_6 H_2O CO_2 N_2 O_2 C_4+	320
Normal 475	15.1	C_2H_4 - C_3H_6 C_2 or C_3	85

To comply with the very stringent requirements of the Air Pollution Control Branch of the Dept of Health of New South Wales, a Flaregas 'FS-18' Anti-Pollutant Smokeless Flare Tip was employed. To satisfy a further requirement of this Authority, to handle the normal flow rate, a special FSU-4" Smokeless Tip was supplied.

From CANADA -

The first Anti-Pollutant Smokeless Flare System has been delivered to Gulf Oil of Canada Limited for their Point Tupper Refinery at Nova Scotia. Supplied through the Ralph M Parsons Organisation in England, the system includes a 24" diameter stack, 135 feet overall height, guy-supported, complete with an 'FS-24' Anti-Pollutant Smokeless Tip and 24" Flarex Seal. The 3" Continuous Pilots are ignited by means of the unique Flaregas non-electric Triboliter Flame Front Generator Panel. One piece erection of the complete stack was made possible by using a Flaregas 'strong-back'.

The equipment has been designed for the following conditions:-

Flow Rate (lb/hr)	Mol Wt	Composition	Temp °F	Pressure at Base of Stack
175,000 (includes 2,200 lb/hr SO_2)	18.7	C_2 C_3 C_4 Rest C_1 & H_2	570	3 psig

An article published in "Oil and Gas Journal" May 25, 1970, describes the strenuous effort made on the part of Gulf Oil to provide a pollutant free plant.

Of the Flare System, it stated this:-

"Smokeless Flare

A newly developed Smokeless Flare by Flaregas in the United Kingdom, is being installed. The Tip is 24 ins in diameter, and is capable of smokeless combustion up to 85,000 lb/hr of 18.7 molecular weight gas.

Because of its unique system of aspirating steam into the burner head, steam consumption is lower than usual. Another novel feature is the ground-level ignition system, which does not require a power supply. A heavy-duty flint supplies the necessary energy to ignite the air/fuel mixture."

Commissioning of the plant is scheduled for February 1971.

From FRANCE - Our Agents and Associated Company -

Airoil Francaise S A R L
23 Rue de Lille
94 Maisons Alfort
France

Negotiations have been completed with GEXA/Technip for the design, engineering and supply of a complete Flare System for the Orenbourg (USSR) Natural Gas Purification and Sulphur Production Plant.

The complete system has a value in excess of £250,000. It comprises six guy-supported Flare Stacks, three of which are 5 ft in diameter and 90 metres high, the other three being 2'-6" diameter, also 90 metres high. The original concept was for one of each size of stack to be tied together as a pair and the combined structure guy-supported by four sets of six guy wires. In spite of the complexity of the problem, Flaregas Engineering Department, making full use of our computerised stack design facilities, produced a complete engineering solution.

During the long technical negotiations, and as a final decision, the customer decided in favour of six individual stacks, each one guy-supported. Each of the 5'-0" diameter stacks is equipped with a Flaregas FN-60" Flare Tip, 60" Flarex Seal and Flaregas Disentrainment Drum. The non-electric 'Triboliter' Panel provides the means of ignition for the four pilots. Each of the 2'-6" diameter stacks is equipped with a Flaregas FN-30" Flare Tip, 30" Flarex Seal and Flaregas Disentrainment Drum. The non-electric 'Triboliter' Panel provides the means of ignition for the three pilots.

During the initial stages, two scale models were produced to provide a clear indication of the intention.

The completed system is scheduled for delivery in December 1971.

From GERMANY - Our Agents and Associated Company -

Pulsation Controls (GB) LTD
4 Dusseldorf
P O Box 6433
Western Germany

report that the first joint venture between Flaregas Engineering Limited and Pulsation Controls (GB) Limited is now successfully under way. A Flaregas system incorporating a Pulsation Controls Silencer (in-line) has been purchased by Uhde for Sala, Czechoslovakia.

The system includes a Flaregas Non-Smokeless Flare Tip, series FN-42", a Flaregas Flarex seal, size 42", a 10 metre long 84" diameter Stack Riser, and a custom built Pulsation Controls Line Silencer. An explosion-proof Flame Front Generator Panel is also being supplied to light off the four pilots mounted on the Flare Tip.

The Flarex Seal, Silencer, Stack Riser, Platforms and Ladders are being manufactured in Germany - the Flare Tip and Panel in England.