AN INTRODUCTION TO GAS PRODUCTION

and

A REVIEW OF THE TRINIDAD GAS SCENE

By

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INTRODUCTION :

The importance of natural gas in a developing economy and to the Petroleum Industry itself is of considerable significance. Although the percentage of total income derived by a petroleum producing nation and by the oil industry from natural gas may be relatively small compared to that from oil production/products, this vital raw product plays a very important role in a developing economy. Like the rest of the petroleum industry, development of natural gas is a highly technical and capital-intensive business.

At this stage in the development of Trinidad and Tobago the natural gas situation is of particular importance and is the subject of the second part of this paper. However, for those who are not familiar with gas terminology and some of the major problems in the industry, the first part of this paper entitled "An Introduction to Gas Production" is to promote a better understanding of the gas business and at the same time to assist in the understanding of the second and more important part of the paper "A Review of the Trinidad Gas Scene".

I. AN INTRODUCTION TO GAS PRODUCTION

(a) Types of Gas :

There are basically two types of natural gas accumulations, that associated with crude oil, and that which is not associated but exists in the gaseous state in underground formations. The first type of gas accumulation is commonly called solution gas, as it is in solution in the oil underground. It cannot be produced by itself, but is always produced in conjunction with crude oil and is separated from the oil at surface. This type of gas usually has a shorter, more erratic production life, as it is dependent upon varying, and invariably declining, oil production rates, i.e. the solution gas production rate is not regulated itself - it is a secondary product as a result of oil production.

The second type of gas accumulation is contained in the gaseous state in underground formations, i.e. it is produced on its own, not associated with the production of crude oil. In many cases there is a clear, light oil produced with this type of gas, commonly called "condensate" as it condenses in the form of a liquid at surface and separates from the gas (refer to condensate sample). This type of gas, usually the main source of supply in long-term contracts such as those with T. & T. E. C. and Federation Chemicals, is

usually found in deeper formations and is under high pressure. Another feature of this gas is that its production performance is usually somewhat more predictable as opposed to the solution type gas which is contingent upon, and secondary to, the performance of an oil reservoir.

(b) Development of Oil and Gas Fields:

Oil and gas fields are developed following an exploration "discovery" by "step-out" drilling from the discovery to establish the size and nature of the reserve. The drilled producing wells provide deliverability of oil and/or gas from the reservoir. A combination of geological and petroleum engineering, physics, mathematics and economics is required in this phase of the industry in order to develop and recover the most oil and gas possible for the lowest possible cost. The risks and capital investment are high both in the exploration for, and development of, oil and gas fields, and it is fundamental to the success of the industry that sound, well qualified technical staff and methods are employed, which must be developed through experience and research. Refer to Figure 1 as an illustration of a typical complex subsurface gas reservoir, the Penal gas condensate field of South Trinidad.

(c) Calculation of Gas Reserves:

Before entering into gas sales contracts an estimate must be made of the volume of gas available for sale in the resevoirs. A simplified version of this calculation for a gas condensate reservoir is shown on Figure 2 and takes into account the size of the gas-bearing reservoir, the porosity of the gas-bearing rock (refer to core sample of gas reservoir), the amount of water in the rock and the initial and final pressures. Although this may appear to be a relatively simple calculation, the factors used in the calculation, particularly in the early stages of development of the field, are extremely interpretative and subject to large variations, and therefore result in ever-changing reserve estimates. The gas reserve calculation is a major factor in developing gas contracts, and because of the unknown and problems associated with the calculation it is difficult to enter into long-term contracts before sufficient knowledge about the reservoir is available.

(d) Gas Well Deliverability:

In addition to the reserve calculation, one must establish the rate at which a gas reserve should be produced to recover the maximum amount of gas again at the minimum cost. This again is fundamental in the development of a gas contract as the customer usually wishes a constant or increasing rate of production, whereas the gas-field usually declines as a result of production withdrawals. Hence the known gas reserves and a suitable development and production programme must be prepared in an attempt to match the customer's demands. This, of course, is easier said than done.

Reserve and deliverability problems are even more complex when dealing with solution gas associated with oil production.

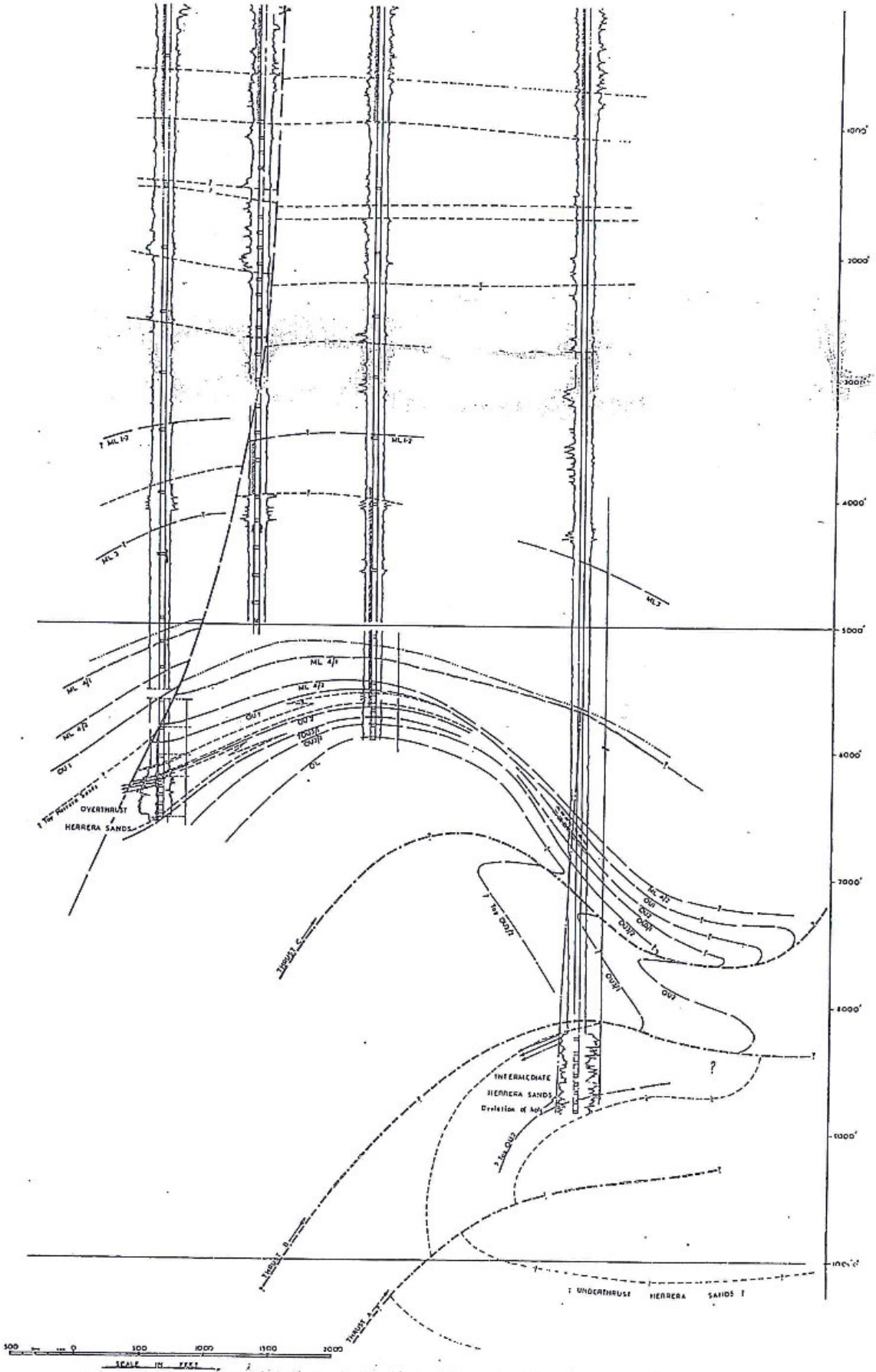
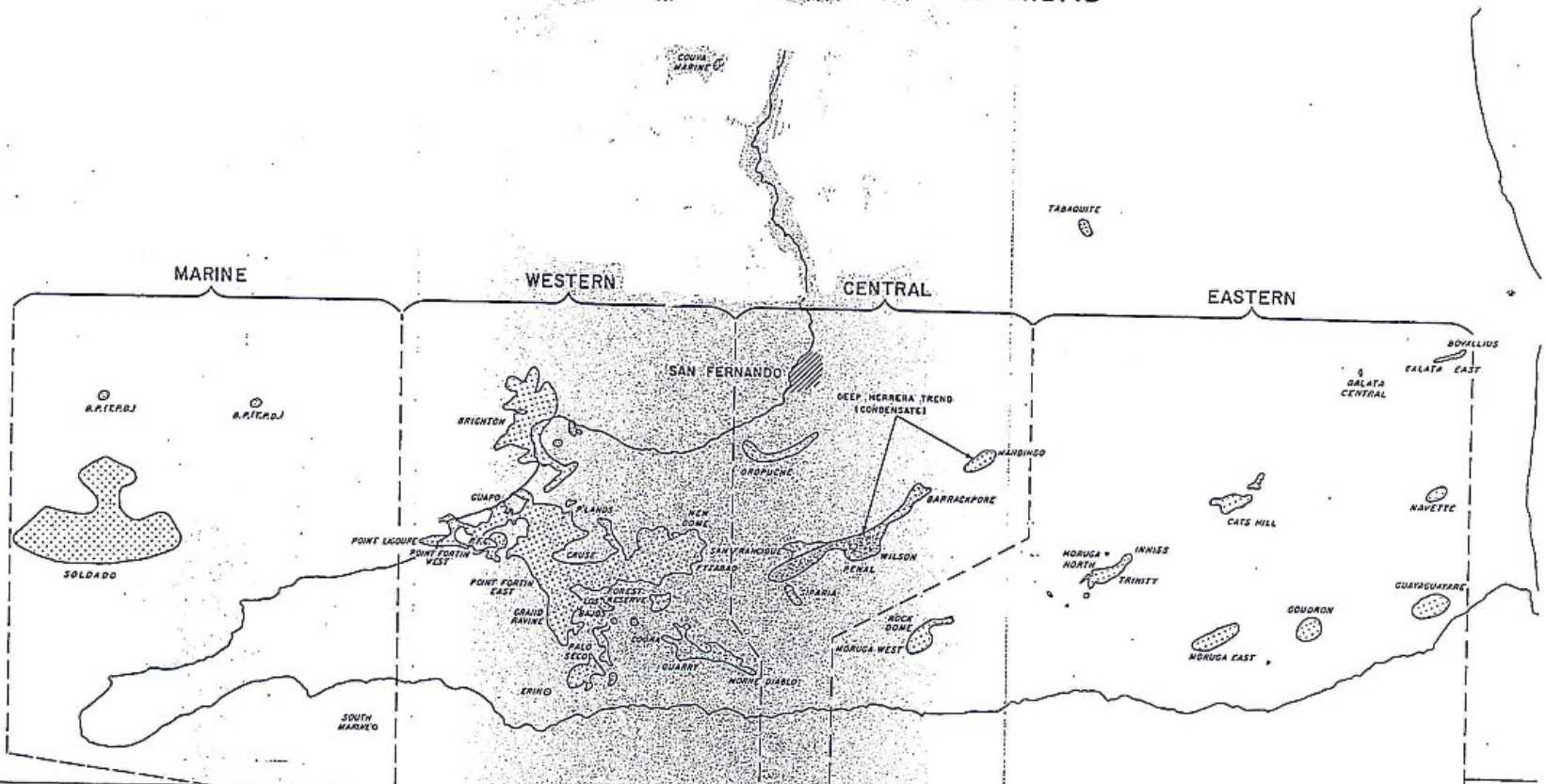


FIG. I SOUTH-WEST PENAL SECTION

OIL AND GAS FIELDS OF TRINIDAD



	MARINE	WESTERN	CENTRAL	EASTERN	TOTAL
Average production rate at 1965/1966 in million cubic feet / day	60	155	90	15	320
Estimated gas reserves 31-12-65 in Thousand million cubic feet	400	750	500	50	1700

(e) Gas Utilisation

Gas has many uses, and every effort is made by the producer to ensure that maximum economic utilisation of this valuable product is developed. The main methods of gas utilisation are summarized below:

(i) **Gas sales Contracts:**

Gas is sold over fixed periods of times at "contract" prices, rates, quality etc. to many consumers for many uses ranging from the raw product in the petrochemical industry to the most common use of gas as fuel for the generation of electricity and heat in many other industries.

(ii) **Refining:**

A large volume of natural gas is used for the generation of electricity, heat and steam in the refining process. This is a natural and logical use for gas when refineries are located in areas of oil and gas production as in Trinidad.

(iii) **Gas Lift (refer to Figure 3):**

Gas is gathered, compressed and injected into the bottom of oil wells which have ceased to flow due to declining formation pressures. The injected gas lightens the column of oil (which frequently contains some water) to where the well continues its "flowing" life and thus precludes the necessity of installing more expensive pumping equipment. This is a high priority use for gas in oil field development and is usually one of the early uses for gas before refineries and sales to third parties are developed.

(iv) **Gas Injection (refer to Figure 4):**

In this case gas is gathered, compressed and injected back into a producing and partly depleted oil reservoir to assist in maintaining the reservoir pressure, thereby increasing the flowing life of the oil wells and, if successful, increasing the total amount of oil recovered from an oilfield, i.e. a form of "secondary" recovery as compared with a "primary" recovery operation such as in gas lift.

(v) **Thermal Recovery:**

One of the latest developments in secondary heavy oil recovery (and this applies to Trinidad) is the injection of heat into oil reservoirs, through the medium of steam or hot water, to reduce the viscosity of heavy viscous oil, add pressure to the reservoir and hence recover what otherwise would be unrecoverable oil (refer to heavy oil sample). Gas is used to generate this "heat" and hence used in another secondary oil recovery process. This use of gas will increase in importance in Trinidad as experiments continue with this process, which, if successful, will lead to the production of this type of oil.

In summary, gas is a multiple use product, and although in many countries it is a small part of the total oil industry, it is an extremely important part. In

all the uses mentioned above, a high degree of technical knowledge plus high capital investment in this high-risk business are required.

You are now all experts in the gas production business, and we shall proceed to "A Review of The Trinidad Gas Scene".

II. REVIEW OF THE TRINIDAD GAS SCENE.

Essentially all of the known natural gas reserves in Trinidad are now fully committed for sale to third parties, for use in refining and in primary and secondary recovery oil production schemes. By the end of 1966 the total gas utilised will be approximately 82% of all gas produced in Trinidad, which is a very high level of gas utilisation. The remaining unused gas is that solution gas which, associated with oil production, is available only in small quantities spread over widely scattered areas. This gas normally declines in step with the associated oil production, and cannot be economically gathered for utilisation, i.e. the cost would outweigh the value of the product. In other words, there is presently no known economic uncommitted gas available in Trinidad.

(a) Reserves:

The Trinidad gas reserve picture is shown in Figure 5 and may be summarised as follows. Total gas reserve in Trinidad at the end of 1965 is estimated at some 1,700 billion cubic feet (1 billion = 1,000 million). At the present rate of production of 320 million cubic feet per day, these reserves would be utilised in 15 years. These reserves are located in four main areas:

(i) Marine-Soldado Area:

There are approximately 400 billion cubic feet of solution gas associated with the oil reserves of the Soldado field.

(ii) Land - Western Fields:

The reserves in this area are 750 billion cubic feet, and virtually all is solution gas associated with the many oil fields present in the western part of the oil belt in South Trinidad. Examples of these fields are Forest Reserve and Point Fortin.

(iii) Land - Central Fields:

The majority of the 500 billion cubic feet reserve in the central area is located in the deep (8,000' - 10,000') Penal-Barrackpore/Wilson/Mandingo trend, which is a high-pressure gas condensate accumulation.

(iv) Land - Eastern Fields:

Reserves of these small and widely scattered fields are estimated at some 50 billion cubic feet. These fields are remote from areas of industrial gas utilisation, and no gas transmission systems exist in the area.

(b) **Production (refer to Figure 5):**

By end 1965 it is estimated that the total Island gas production will be approximately 320 million cubic feet per day, distributed as follows:

(i) Marine - Soldado Area:

Gas production 1965 will average about 60 million cubic feet per day, of which some 32% is now utilised. When the various gas lift, gas injection and gas transmission ashore projects are completed in 1966, the overall gas utilisation will be of the order of 80%. The production of 60 million cubic feet per day is the peak gas production expected from Soldado, and unless significant new discoveries are made in the current exploration/appraisal drilling the gas production rate must inevitably begin declining, probably during 1966.

(ii) Land - Western Fields:

The total gas production is approximately 155 million cubic feet per day; of this some 32.5 million cubic feet per day is utilised in the refineries and in sales to Federation Chemicals Limited, while 80 million cubic feet is used in the fields for gas lift, gas injection and fuel. An increasing use for gas in this area will be for thermal recovery projects, if this new secondary recovery method proves successful.

(iii) Land - Central Fields:

The total daily gas production is 90 million cubic feet, of which 80 million cubic feet per day is high pressure condensate gas from the Penal field and is used for sales to T. & T.E.C., F.C.L. and T.C.L. and for refinery fuel. A small quantity (5 million cubic feet) is used in the fields for gas lift, gas injection and fuel.

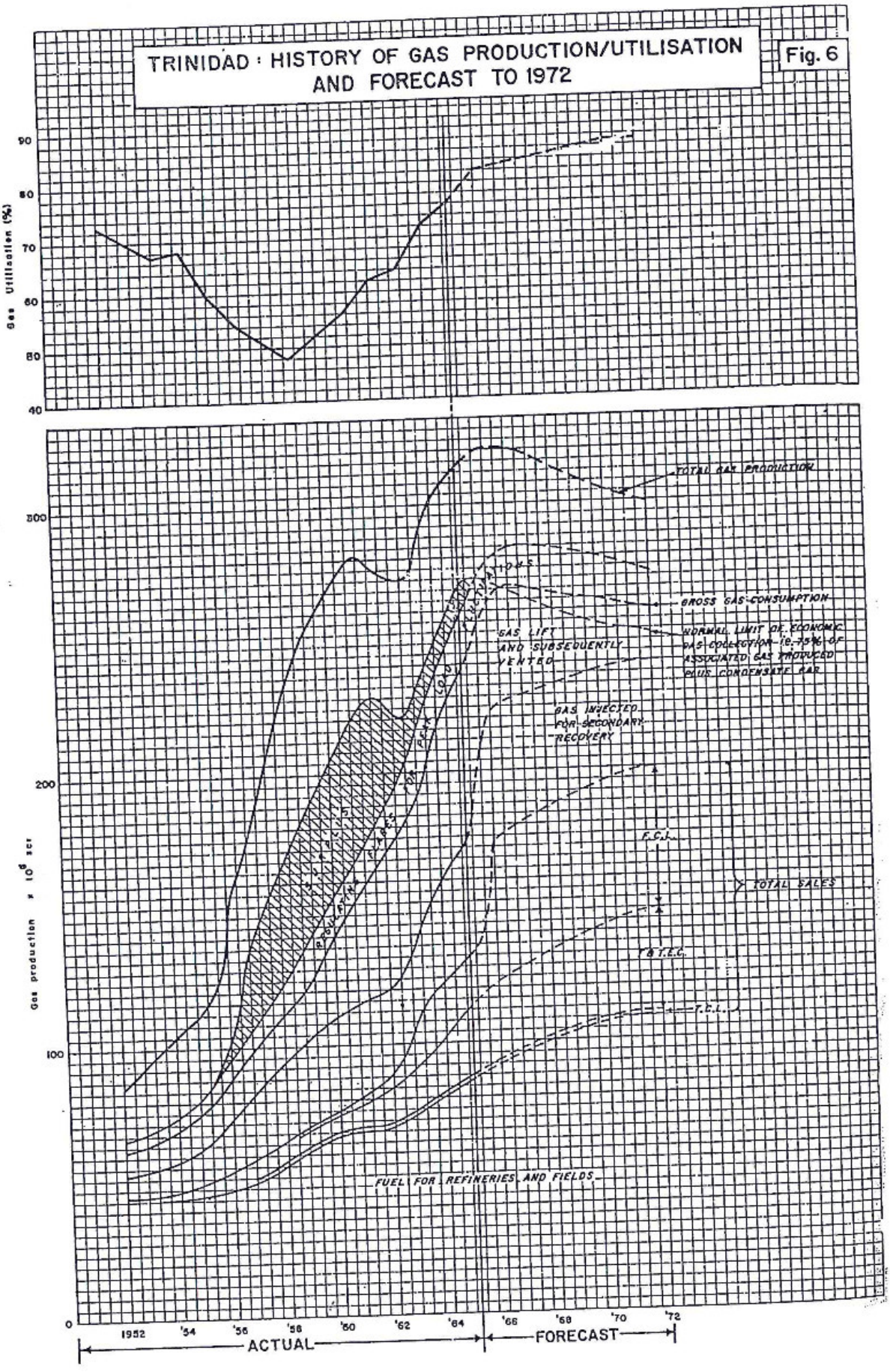
(iv) Land - Eastern Fields:

The total daily production from a number of widely scattered fields is approximately 15 million cubic feet. Some 8 million cubic feet are used in the fields themselves for gas lift, gas injection and fuel.

(c) **Gas Utilisation/Supply and Demand Situation: (Refer to Figure 6 and 7)**

At the end of 1964 the total gas utilisation was about 72%, and by the end of 1966 when present projects now under construction and being planned are completed, this will rise to about 82%, which is a very high utilisation factor.

Figure 6 illustrates the actual and forecast gas production and utilisation. It is of interest to consider this graph in some detail. As far back as 1952 gas utilisation was over 70%; at this time, however, the total gas production was only 80-90 million cubic feet per day. During the period 1954-1959 development of oilfields, proceeded rapidly and, particularly following the discovery


TRINIDAD : HISTORY OF GAS PRODUCTION/UTILISATION AND FORECAST TO 1972
Fig. 6
Gas Utilisation (%)
90
80
70
60
50
40
Gas production = 10^9 scf
300
200
100
0
TOTAL GAS PRODUCTION
GROSS GAS CONSUMPTION
NORMAL LIMIT OF ECONOMIC GAS COLLECTION - 12.75% OF ASSOCIATED GAS PRODUCED PLUS CONDENSATE GAS
GAS LIFT AND SUBSEQUENTLY VENTED
GAS INJECTED FOR SECONDARY RECOVERY
F.C.I.
TOTAL SALES
T & T.E.C.
T.C.I.
FUEL FOR REFINERIES AND FIELDS
1952
'54
'56
'58
'60
'62
'64
'66
'68
'70
'72
ACTUAL
FORECAST

and development of the deep gas condensate accumulation in Penal/Wilson/Barrackpore (primarily for production of condensate at this stage), the gas production increased very rapidly to 250 - 270 million cubic feet per day.

Although maximum efforts were made to use this newly developed gas, the overall utilisation fell to 48% in 1959. (This emphasizes a major problem in the gas industry the time lag that must always exist in gas utilisation between the time gas is discovered and evaluated, followed by a period of planning, negotiation, construction etc. and the time it is finally utilised). By 1960 the utilisation was again improving-sales to T.& T.E.C., increasing use by refineries as refinery throughput increased, increased gas lift and gas injection. The dip in the total production curve 1961 - 1963 reflects a further short-term conservation measure adopted by the oil companies, that of closing in those gas-condensate wells from which the gas, as well as the condensate, could not be utilised. This entailed a significant deferment in oil production, i.e. condensate, from the wells affected, but this was accepted by the companies concerned as a worthwhile price to pay for conserving the high-pressure gas for subsequent utilisation.

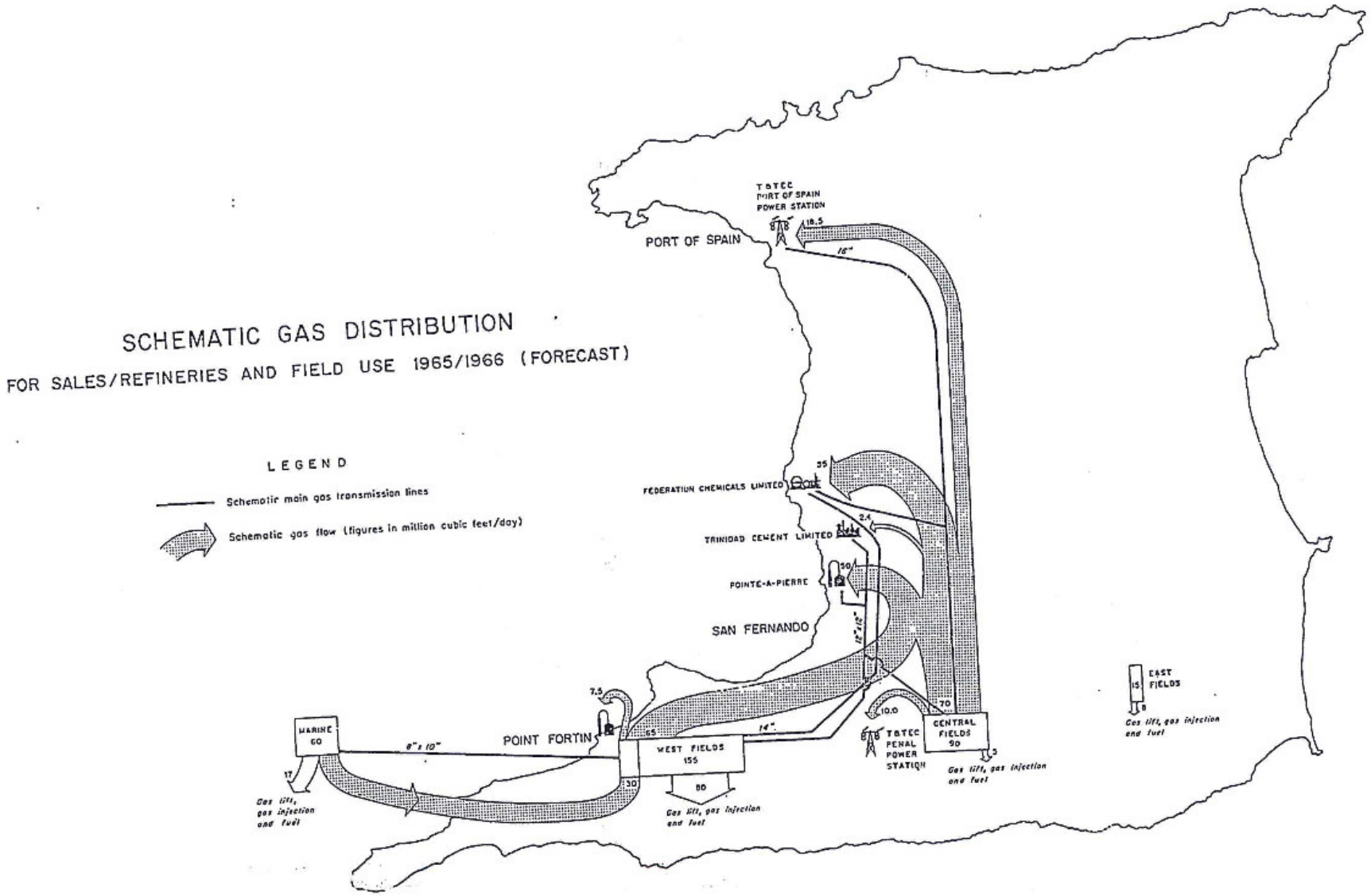
Further increases in sales, refinery and field use, since 1963 have now virtually eliminated the surplus gas production situation, and from figure 6 it can be seen that by 1966 it is expected that the total gas consumption will have reached 264 million cubic feet per day, 82%, of production at or very near the economic limit of gas utilization. At this time the breakdown of gas utilisation will be as follows:

		Million cubic feet/day	
Sales:	T. & T. E. C.	28	
	F. C. L.	55	
	T. C. L.	2. 4	
Total sales:			85.4
Fuel for refineries and fields		91	
Primary and secondary recovery oil production schemes		88	
Total own use			179.0
Total utilisation:			264.4

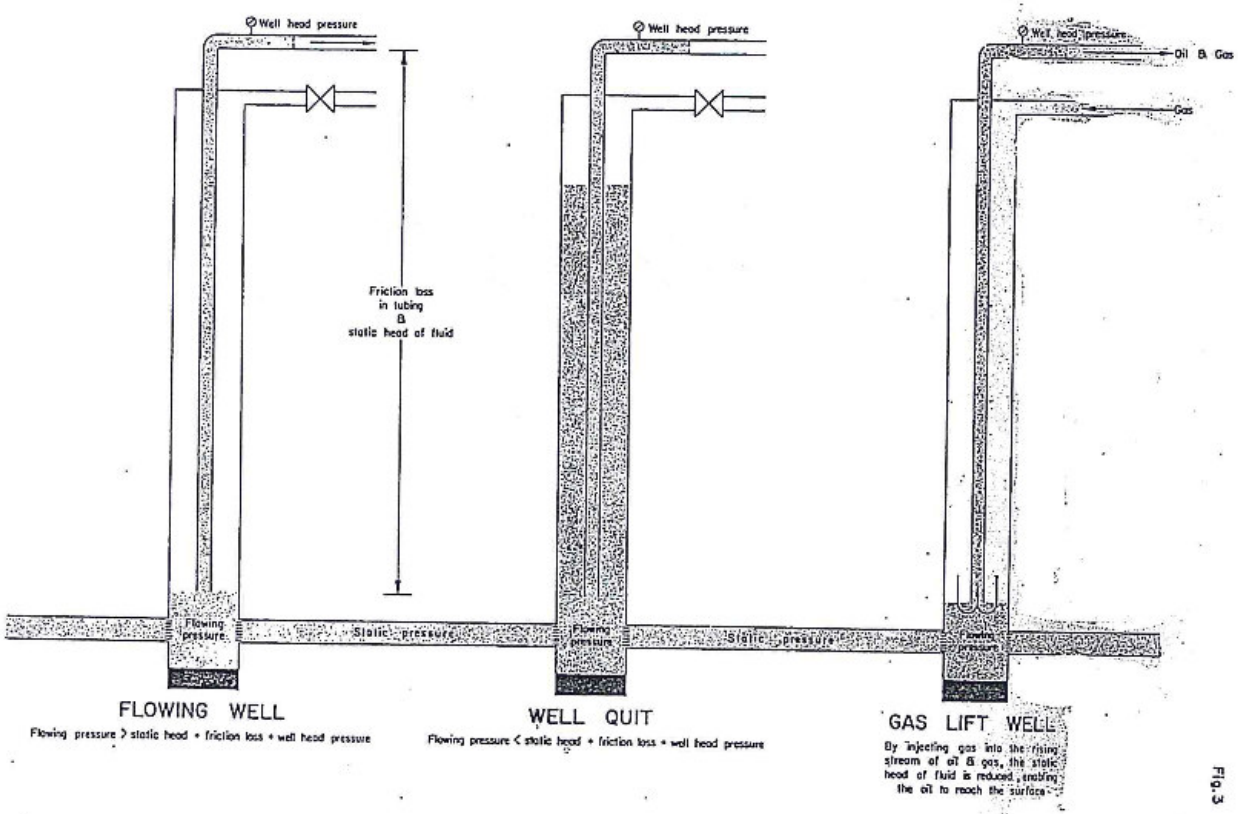
Fig. 7

SCHEMATIC GAS DISTRIBUTION

FOR SALES/REFINERIES AND FIELD USE 1965/1966 (FORECAST)



SCHEMATIC GAS LIFT PRODUCTION



FLOWING WELL

Flowing pressure > static head + friction loss + well head pressure

WELL QUIT

Flowing pressure < static head + friction loss + well head pressure

GAS LIFT WELL

By injecting gas into the rising stream of oil & gas, the static head of fluid is reduced, enabling the oil to reach the surface

Fig. 3

SCHEMATIC GAS INJECTION

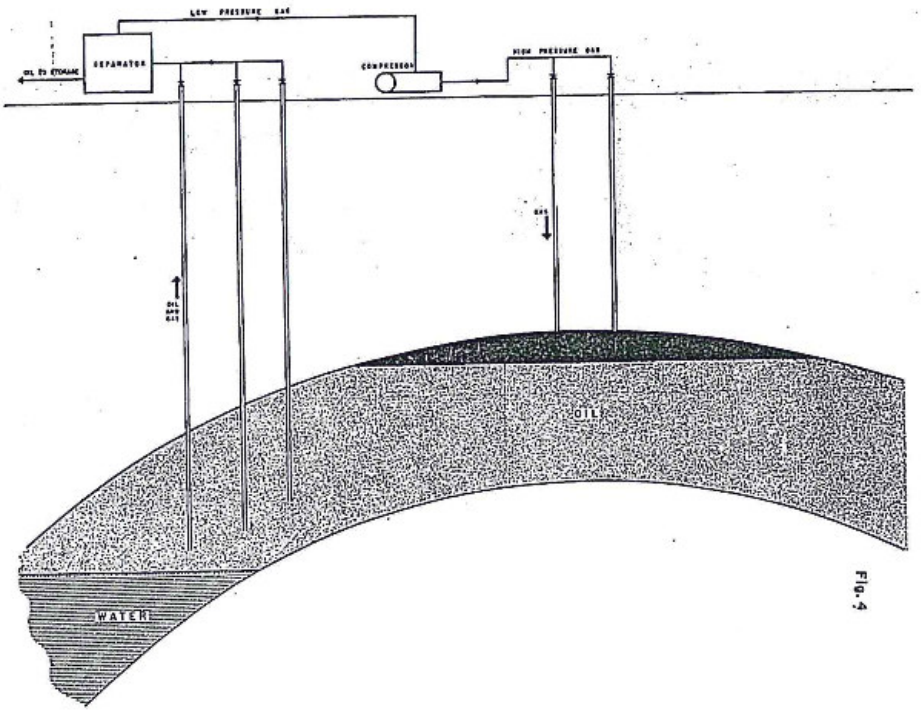


Fig. 4

VOLUMETRIC CALCULATION OF GAS RESERVES

GAS FIELD

$$G = 43560 \times V \times \phi \times (1 - Sw) \times E$$

- G: (Gas in place scf.)
- V: (Net gas sand volume in Acre ft.)
- ϕ: (Porosity)
- $(1 - Sw)$: (1 − Water saturation)
- E: (Gas expansion factor)

The graph also illustrates that gas production is expected to peak in 1965/1966 at around 320 million cubic feet per day, declining thereafter unless new gas reserves are found. The graph demonstrates quite clearly that, on the present estimates of future committed gas demand, the surplus gas which existed prior to 1964/65 no longer exists and that gas utilisation will be running at around 85% in the next year or two, which is an exceedingly high figure. It also suggests that, on the figures shown, the oil companies themselves will have to cut back their own uses after 1966, e.g. reduce gas lift by converting to more expensive pumping, reduce gas injection or even reduce refinery use by burning fuel oil, which is also more costly than burning gas. This will have to be done in order to fulfil existing gas contracts with third parties.

Figure 7 illustrates the origin, distribution and utilisation of gas in Trinidad. This illustrates the gas producing areas in South Trinidad and the transmission systems to take this gas from the producing areas to the areas of utilisation, namely the two T. & T. E. C. power plants, the two oil refineries, Federation Chemicals Limited and Trinidad Cement Limited plant. From this it will be seen that the total production of the Island, through an integrated distribution scheme, is fed to the various plants utilising natural gas. It will also be noted that a large share of the gas, some 107 million cubic feet per day, is used in the industrial Point Lisas - San Fernando area.

(d) Future Gas Prospects:

As all existing gas reserves and production are now fully committed, the only prospect for future expansion of the gas industry is in the location and development of new gas reserves. This, of course, involves new exploration effort, and there are two main areas which indicate some potential for finding new reserves. These are in the high-pressure gas condensate area of Penal where further appraisal drilling is being carried out in an attempt to find new reserves and in the offshore, including the Soldado area already mentioned, as well as possibilities in other offshore areas of Trinidad. These areas are highly speculative, and only future costly exploration drilling will prove the presence of oil and/or gas. Even if success is obtained in exploration drilling offshore, experience to date indicates that the gas would likely be of the associated type, and a development period of 4-5 years would be necessary before any sales contracts could be negotiated and implemented.

Point Fortin.
28th June, 1965.