Field Compression Of Natural And Casinghead Gas

By GLEN L. POOL
El Paso Natural Gas Company

R. F. SPIKES
Pioneer Natural Gas Company

INTRODUCTION

Field compression of gas is an entirely different problem from main line compression. In main line stations, dependability and cost of operation are paramount considerations. These are not always the case with field compression.

The compression of natural and casinghead gas, in the field, is accomplished largely by the use of packaged reciprocating compressors. These units are used to boost gas from wells to gathering system trunks on small gas fields, to main line pipelines and for recycling gas for oil recovery.

The purpose of this discussion is 2 fold. First, it is felt that those who have not been involved in this type of operation heretofore may fail to foresee some of the problems that should be considered in the design of a field compressor unit installation. Secondly, some of those who are already operating these units may have problems which they have not worked out to their satisfaction and may gain from the experience of others. No attempt will be made to enter into the techniques involved in the actual design of skid mounted units or any of the accessory equipment since there is a wealth of material on these subjects available from various sources, nor will the use of any particular type or make of compressor unit be advocated.

GENERAL

In gathering natural gas the systems are usually designed for gathering at field pressure in the beginning. But at some point in the decline of field pressure it will be necessary to install field compressors. There are 2 major reasons for this and both, of course, are economic reasons. The installation of a gathering system which would serve the field to a calculated abandoment pressure is invariably too expensive and would also require much more investment than is required to produce the field in the first few years of operation. Field gathering systems are normally designed to produce at a given central location for a certain period until the installation of field compressors must be undertaken to get the gas to this central location.

Casinghead gas is gathered in the same manner except that much of it is available at pressures which require compression from the beginning. Some of this gas is gathered from tank batteries and when the vapors are collected from these tanks they are gathered at or near atmospheric pressure. At these extremely low pressures it is always more economical to push the gas than to try to pull it; therefore, the compressors are located near the wells and batteries.

Field compressors are also installed for the purpose of increasing the production of oil from a field. They may be used for primary or secondary recovery, or both, and this may be used in connection with the sale of gas. In efficient use of gas lift for primary recovery, lift gas source and recovery are vitally important. Lift gas, used to lift oil in wells that will not flow, is recovered along with the gas normally produced from the well; therefore, you must have a source of gas as well as a place to dispose of the surplus. The source gas can be from other wells in the field which flow or which are pumped by conventional means. The surplus gas must either be sold or reinjected into the field for secondary recovery purposes.

Primary oil lifting by a packaged field compressor is being accomplished on a lease in Lea County, New Mexico, by use of a 2 stage gas engine driven unit, boosting approximately 1 million ft of gas from 45 psig to about 850 psig. This unit takes casinghead gas from the gas-oil separators and recycles it back to the five wells for lifting service. Make-up gas is received by regulation from a nearby low pressure gas gathering system. Approximately 17,000 BOPM are lifted by this equipment.

A typical example of the use of packaged field compressors is shown in Figure 1 in which a 190 bhp packaged unit is used to compress natural gas from five wells through a 4 in. lateral line to a 10 in. high pressure gathering trunk (Figure 2). Normal load for this service is 2 million cu ft of gas per day. In the very near future the unit will be moved to the junction of this 4 in. lateral and the 10 in. trunk where the load will be increased by adding 2 more wells to this service. These wells could have been tied into a lower pressure gathering system by laying several miles of 6 in. diameter pipe. However, the economics and convenience favored compression into the existing system.

Installations of this type are made until lower pressure gathering systems can be justified and changes made in existing major gas handling plants to process the gas at lower pressures.

It is quite obvious that flexibility is one of the main features of this type unit. A 150 bhp packaged

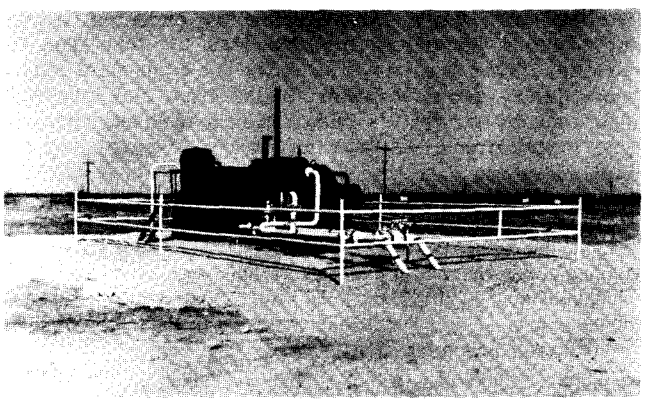

Fig. 1

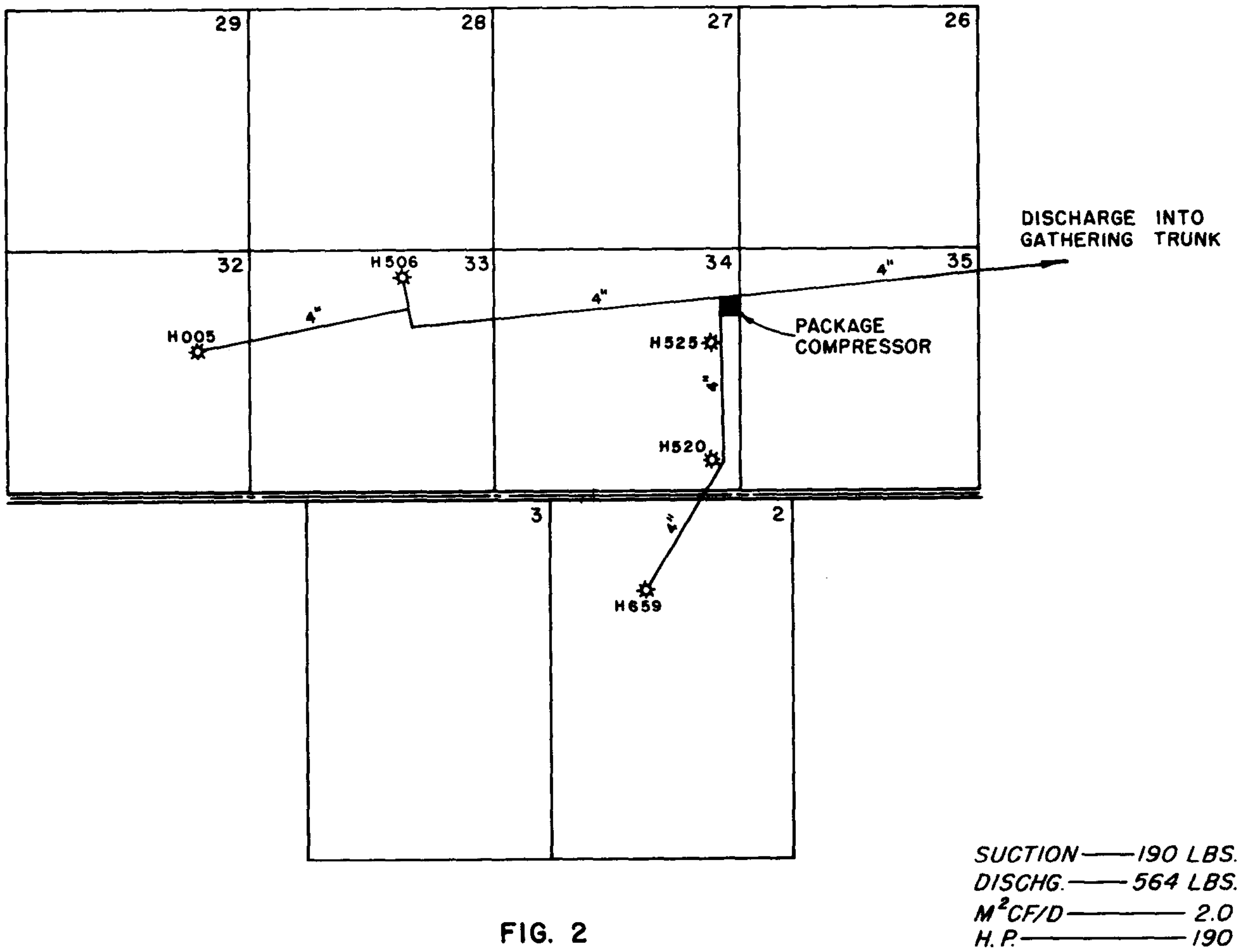

FIG. 2

unit might be used to boost gas from 1 to as many as 12 wells in the area and can be relocated and put into service in about 2 days. This does not involve a great cost since the separator, coolers, and all shutdown controls are located on the skid. Usually the unit is located near the pipeline so that only short leads from block valves are required to be tied in for service. The concrete block or piers are poured for the unit itself and piping piers are poured after the unit is set. Installation costs range from $1,200 to $2,500, depending upon the unit size and the site separation.

The packaged compressor may be used for area gas boosting service where semi-remote locations are involved or where the service is expected to be short-lived. Packaging compressors for this type of service allows the owner to move the equipment more conveniently from location to location, and involves less expenditure for the installation than for permanent type installations. Another advantage to packaging or skid mounting the machine is that additional horsepower may be added in small increments at lower cost and with greater flexibility.

Area gas booster stations usually are installed in horsepower ranges from 1,000 to 5,000 and are equipped for daylight manning only. These stations are often more of a permanent type of installation and in most cases are housed.

SELECTION AND INSTALLATION

The selection of a packaged unit for gas booster service in the field is based upon the following considerations;

1. Volume and pressure ranges
2. Quality or type of gas
3. Location and maintenance available
4. Life of the installation
5. Type of operation
6. Availability of parts and service

Manufacturers basic brake horsepower curves are available to be used for determining total compressor horsepower requirements after the compression ratios and volumes have been established. These curves give brake horsepower required per million cu ft of gas per day to be compressed by virtue of the compression ratio and "N" value or composition of the gas. Where low compression ratios are concerned the following formula may be used to estimate the compressor brake horsepower requirements:

$$bhp = 22\,(R_c)(V)(S)$$

WHERE:

bhp = Brake horsepower required
R_c = Compression ratio
V = Volume of gas (million cu ft per day)
S = Number of stages of compression

The power units should be derated at least 40% in this area due to the altitude, temperature and accessory equipment.

In field uses where accurate suction pressure ranges are not easily determined the compression cylinders are usually oversized. This is done for 2 reasons. First, if the suction pressure to the unit is lower than anticipated one can move the required amount of gas by decreasing the clearance volume in the cylinder and if it is higher than anticipated one can either increase the clearance or run the cylinder single acting. Secondly, if one moves the cylinders to a new service he may need the larger cylinder but if one needs a smaller one he can always re-line it to a smaller size with very little expense.

Due consideration should be given to the type of operation one anticipates before deciding what type of equipment to install. Equipment that is suitable for attended operation may not be nearly as well suited for unattended or remote operation. This decision, of course, is also dependent upon the overall importance of each individual station to the particular system involved.

There are three separate and distinct types of engine drivers which may be used in these installations and each one has certain advances which make it the right choice in some situations. The large slow speed integral compressor units can be used for locations where bhp requirements approach, or are in excess of 1,000. These units are dependable and economical to operate but the original installation costs are high. They are also heavier and not so portable as other types, however, these units are skidded by some people. The medium speed integral compressors (450 to 600 rpm range) and the high speed (1,000 rpm) compressors with separate engine drives are the most commonly used machines for field compressors. Again the medium speed units are the most dependable and economical of the 2, but they cost the most to install. The high speed compressors driven by the separate industrial 4 cycle engines can be installed more economically and are as dependable as is necessary in most cases. This statement means simply that if it is relatively easy to get along without the group of wells for short periods, it is unnecessary to spend extra money to install a machine that gives the promise of more continuous availability.

Most people contend that it costs much more to operate the high speed compressors. This may have been so at one time but now there is very little difference. The difference is that one must size the engines right, hold the engine speed down to a reasonable figure, and otherwise operate these higher speed engines in such a manner as to get good performance. As do the heavier duty engines, they will not take abuse and sloppy operation without increasing the cost of operation.

With the advent of the high compression engines for use with natural gas fuel only, the 4 cycle industrial engines started to approach the fuel economics of the heavy duty engines. The value of this difference in fuel consumption has been overrated considerably. The cost of this fuel, so near the wellhead, is certainly not as much as it would be at the last main line compressor station after pushing it half way across the country. Of course this is not conversation talk, but other than on that basis, it is hard to justify an increase in investment strictly from a fuel economy standpoint.

Experience has shown that in order to get satisfactory performance on these high speed engines they must not be overloaded. In addition it has been determined that the speed must be held down below the maximum speed recommendations of the manufacturers. Engines of the same type and size have been operated at different speeds to prove this statement. It was found that an engine which is normally sized at 1200 rpm had a bearing life expectancy of only 8,000 to 12,000 hr at this speed. Those which ran at 1000 rpm would run about 18,000 hr before the bearings needed attention. One engine which ran at 900 rpm has run as long as 40,000 hr without trouble. After learning how to size and apply them, it was almost impossible to prove that they were more expensive to operate than are the heavy duty engines in the services in which they are applied.

Since there are several firms who package compressors, competitive bids may be desirable. Solicitations for these bids should be thorough, since there are usually many optional items of equipment that can be considered for this type of unit. Primarily, of course, the manufacturer must be given the volume, pressure range and quality of gas to be compressed and the services available. He should be given maximum pressure fluctuation so that unloading bottles may be considered. Large users of this type of equipment usually have standard specifications and must add to these only the information regarding the gas volumes, pressures and quality for each request for bidding. A single stage skid-mounted compressor with gas engine belt drive, inlet scrubber, clutch, normal safety shutdown equipment and water-oil cooler in the 150 bhp range should cost about $135.00 to $150.00 per bhp required for gas compression. This represents the average size unit for field gas boosting service. Two stage units with heavier frames, interstage gas cooling etc. may cost around $200.00 per bhp of compression required. The installation costs must be added to this price to find the installed price. The installation costs will vary from one location to another depending upon the extent of housing and other site improvements required.

In a natural gas field, the gas to be moved depends on the sales demand and the allowables on the wells in the field since these fields are normally used to take the swing in demand for gas from utility companies. On the other hand, casinghead gathering systems are sized to handle the gas produced along with the oil, and gas sales demand is not a factor beyond the fact that there must be a place to dispose of this gas. Of course, under present conditions in Texas it is not necessary to install compressors to handle the total production from a field since the wells can only be operated around 8 days per month and staggering the production so that some wells are produced all month will allow smaller gas handling installations and more nearly constant operation of these facilities.

Consideration of the location for future compressor sites should be made when the gathering system is originally designed. In most cases this will allow the use of one compressor site to pump from several wells so that each individual station will be of a reasonable size. If this has not been done in the original plans for the gathering system, it should be done at the time one begins adding compressors. One can almost invariably find a way where it is more practical to run a little pipe to hold down the number of stations and install larger units which are more economical both in installation costs and in operation and maintenance costs. As an example a 1,000 bhp unit can be installed at one station for about 70% of the cost of installation for ten 100 bhp units at different locations. It should be obvious that it will cost more to operate 10 compressors at 10 separate locations than to operate 1.

Site location is not a very hard job in flat, level farm country, but if one picks a site from a map he may find himself building a station on the face of a cliff, on a sand dune or in the middle of a dry wash which is not always dry. The point is, some flexibility of location should be built into the system or else the system should be built so that one has acceptable locations where they are needed. It may be that the site locations will dictate the maximum size of the equipment one may install. It could be very embarrassing to find that one has purchased equipment too heavy to get to a location over existing facilities.

The location and expected life of the installation will determine the expense of items such as housing, fencing, and hard topping of the compressor site. Complete housing of a remote field unit is very seldom done in the Permian Basin Field where snow and rain are not frequent enough to hamper operation. Insurance costs are also lower for incomplete housing. In the Panhandle Field where the weather is more severe, housing is normally required. Low cost fencing is usually provided to protect the equipment from cattle. All blowdown pits, of course, must be fenced. The site is often covered with caliche especially in sandy areas, to allow access of vehicles for maintenance.

Accessory Equipment

Now that the type of major equipment which will be installed has been discussed, it is necessary to give some consideration to the accessory equipment.

One of the most important pieces of equipment as far as the compressor is concerned, is the scrubber. Gas containing slugs of free water or liquid hydrocarbon will damage a compressor. Usually a dry type scrubber with a liquid damp trap and a high level shutdown device is all that is required; however, these have been found to be inadequate on occasion and for different reasons. At one station, compressor valves and rod packing were lost faster than they could be changed out. Operations personnel brought in samples of fine gritty sand which they found in the cylinders. This sand was identified as being from one of the producing formations in the field and it has passed through the dry scrubbers on the packaged units. An oil bath scrubber was installed on the station header and the trouble stopped. At another field it was found that salt was being deposited on valve plates and rod packing causing leakage. The solution to this problem was also an oil bath scrubber. Most installations take fuel gas down stream from the scrubber and do not use a filter on it. Using a filter on this fuel gas might be a good safety device. The filter should plug up and shut the unit down giving an indication of trouble before damage is done.

As far as the engine is concerned, it must have cooling to run. Normally a unitized cooler with a vertical discharge is installed. The air intake should be faced South or West since that is the direction from which the prevailing winds blow in the hot months. In many installations, aftercooling is not necessary and considerable money can be saved by using only an oversized industrial radiator. Even though the discharge temperatures from a compressor may be quite high, one will do very little good by cooling a stream of, say, 1 million cu ft per day and then dumping it into a stream of 60 million per day which is flowing past the station at ambient ground temperature. One of the disadvantages to gas aftercoolers is that they are sized for summer-time and in the winter one may have to throw heat on them to keep hydrates from forming.

Field units are designed to run unattended at least a part of the time. The very minimum of shutdown devices required are those necessary to protect the engine and the compressor. Ordinary safety devices for the units are:

1. Low oil pressure switch
2. High jacket water temperature switch
3. High and low suction and discharge pressure switches
4. Discharge gas relief valve
5. High discharge temperature shutoff switch
6. High scrubber level switch
7. Vibration switch
8. Overspeed shutdown

All the shutdown safety switches are provided to ground out the magnetos on the power unit in case of abnormal operation. For a nominal price, one may have installed a tell-tale or annunciator panel which will tell the operator what caused the unit to die on the line. A pressure controlled regulator may be placed between the discharge and suction header to bleed discharge gas to the suction and prevent overloading of the unit during periods of low suction or high discharge conditions.

What happens to a unit which is set up to be attended once a day, when a blizzard blows in and one cannot get to the location for a week? Nothing, if one has planned for that eventuality. Exhaust gas condensors can be utilized to furnish make up cooling water for field units. These work well if they are placed in front of a fan where air is drawn over them. Glycol should be used in the winter so that freeze ups will not occur. Condensate or demineralized water should be used in water systems to prevent scaling of heat transfer surfaces. Corrosion inhibitors may be added if the water quality warrants it. Automatic oil make up devices may be installed to maintain crank case and lubricator levels, if the unit cannot be attended daily. These instruments meter oil to the unit from the oil storage as needed. With these devices installed, and if everything goes well, a unit stays on the line and one does not have to worry about it.

If it is necessary to house the units, it will cost very little more to place the air intake in the building wall and duct the air out of the building, in the case of unitized coolers (Figure 3), or oversize the roof ventilators in the case of radiator coolers. This will permit operations with the building closed and locked and will discourage prowlers who have been known to shut down engines and walk away with everything they could get loose on a unit.

There are several types of starting devices for the power units. If gas pressures on the site are sufficient an air-gas starter is usually selected. If the suction pressure or lease gas pressure is too low for this type of starter, battery-electric starters may be used. Other choices, of course, are small engine

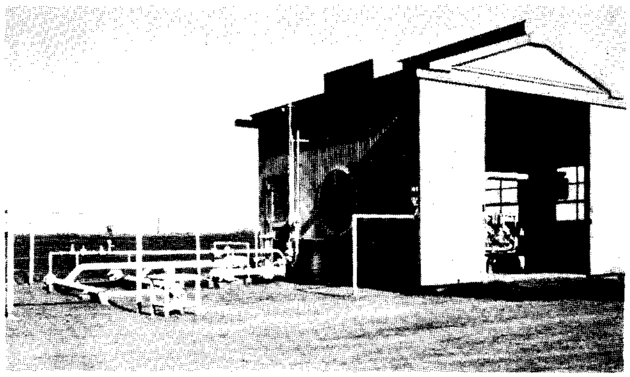

Fig. 3

starters and engine driven air compressors which may be mounted on the skid beside the power unit.

Referring again to Figure 3, one will note that all the piping is above ground and there is an extra set of bottles in the suction and discharge line to each unit between the header and the building. These bottles are in addition to those which are installed on the compressor unit itself. Precisely engineered pulsation dampening equipment is not feasible on field units, because of the widely varying suction and discharge pressures. Therefore, "rule of thumb" type bottles may be utilized for dampening problems. Referring to Figure 4, one will note that the bottle is twice the nominal pipe size of the line pipe as indicated by the dimensions D & 2D. The actual configuration of the bottle must be as indicated by the dimensions L and 2L. One of these bottles is placed in the suction line to the unit so that the gas flow dead ends into this bottle while the suction line tees off and goes around the bottle to the unit. The bottle in the discharge line from the unit is installed in the same manner. For want of a better name these bottles are referred to as "Resonance Bottles". The actual use of these bottles was worked out on field compressor installations but they have been applied successfully at main line stations.

OPERATIONS AND MAINTENANCE

Most field stations are operated unattended: that is, one operator operates several stations and only stops by daily to perform necessary house-cleaning chores, do minor repair work on the unit, and make sure that the engine and compressor are both operating satisfactorily. The operator must have transportation and since he is on his own most of the time, one should be able to reach him by radio in the event that there are changes in field operations which require changes in operations at the stations. Most field compressor operations grow gradually. The first 1 or 2 stations are nearly always operated as satellite stations out of a larger main line station. Alternatives to this would be to let the field men operate them or let out the operation on a contract basis. It is believed that both these alternatives are unsatisfactory, but there are situations where an unsatisfactory solution is the only solution to a problem.

The point has been made before that equipment will operate more economically if it is operated well. If one is depending on field men to run his compressors, their primary concern is producing the field and they will do that no matter what it does to the engines. When the compressors go down they can call for the repair crew or blame the equipment or both, but at least they are not likely to take the blame themselves. They cannot be expected to produce the field if the compressor will not stay on the line. Contract operation is very little better. It is tough to pin down the responsibility for troubles when one has purchased equipment from someone and is contracting with someone else to do the operation.

There is no set rule for the number of stations that can be successfully operated by one man. If they are all easily accessible and in close proximity, one man can handle several stations. If one feels that good housekeeping is unimportant and that the units only need attention when they stop running, he can operate more stations than if he thinks the other way. Some operators feel that it is money well spent to keep their field stations up to practically the same standards as those of their main line stations.

In the event that one only has a few units and feels that he only needs one operator, he can furnish relief for this operator during his days off by replacing him with a man from the repair crew. When the number of units increase to the point that one man cannot give the kind of operation one beleves that he needs, then another operator should be added and allowed to overlap three days a week. As the field compressor units continue to be added, one may reach the point where he will have to split the stations between 2 operators. At this time a third operator can be added and he will fill in for each of the regular operators 2 days a week. There is usually enough record keeping and parts requisition work to keep him busy for his other day.

There are people who have field stations fully attended, or at least they have people living at the location who are on call all the time, but it is really an important station which requires this kind of operation. Recently, we have noticed that some of the operators are installing remotely operated field compressor stations. The ones that have come to our attention have been equipped with 60 watt alternators to furnish power for the telemeter operated controls. These units can be automatically started and stopped and the capacity and speed can be changed from a remote location. There is considerable expense involved in an operation like this and it would have to be a very important station to justify this expense since one would still require the same type of operation and maintenance set up which has already been described for unattended operation. The only thing gained is the ability to put the unit on and take it off without waiting for someone to get there and also to do it during bad weather when no one can get there. In most cases these advantages can be circumvented by other means.

The heavier maintenance work on field stations as well as on some of the main line stations can be handled by traveling repair crews. In most cases, a 3 man crew would be considered a very minimum sized repair crew since sometimes 1 of these men is used to fill in as an operator at field stations. Actually 4 is a better number since it allows one to split the crew and have work being done on 2 locations at the same time.

In the event one does not have enough work to justify a full time maintenance crew, then the only alternative is to hire the work done on a contract or extra work basis. This arrangement should be avoided if possible, since it is not likely that one can control the quality of the work as well as when he does it with

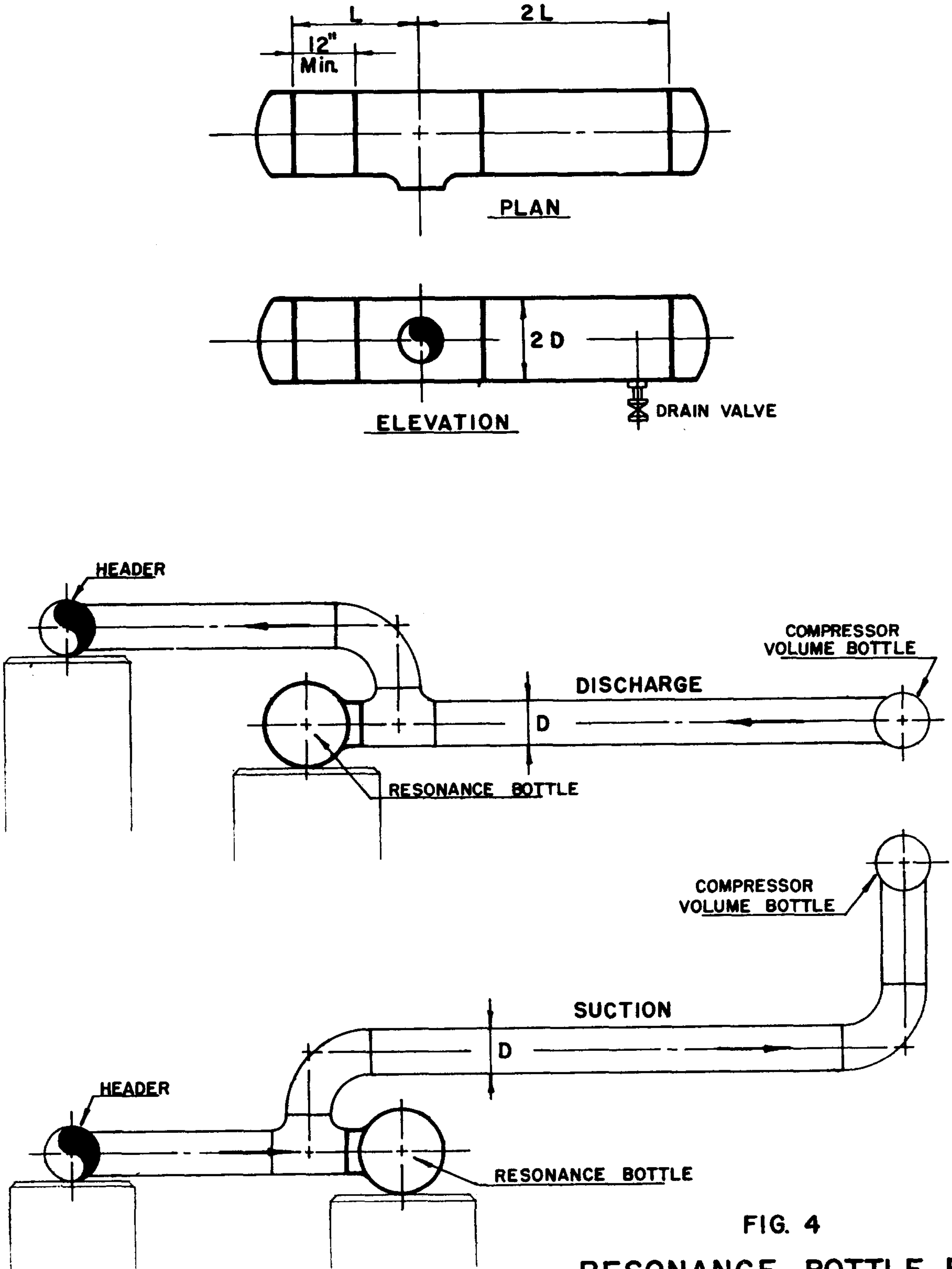

FIG. 4

RESONANCE BOTTLE FOR GAS COMPRESSORS

his own people. There are cases where it would work out well but these cases are probably the exceptions not the rule.

MAJOR DIFFERENCES IN COMPRESSING NATURAL AND CASINGHEAD GAS

The major difference in handling natural and casinghead gas is in the quality and pressure of the gas handled. Most natural gases are drier, have a lower heating value, and are generally acceptable fuels to use in engines with high compression ratios which can only be used on natural gas fuel. The fuel for these engines is supposed to contain no more than 1,000 BTU per cu ft of gas; however, fuel with a heating value up to 1,075 BTU per cu ft has been used with no apparent trouble. Casinghead gas has a much higher heating value and one usually has liquid fall-out problems. There is a certain amount of crude carryover in casinghead gathering systems, and the troubles can range from a line stoppage because of a paraffin build up to troubles in the fuel system because of oil in the fuel.

An operator is compressing casinghead gas at 1 location where the crude oil will not flow at temperatures below 40° F. The station scrubber would catch the oil but it would not flow out of the scrubber in cold weather. This problem was solved by diverting part of the engine cooling water to the scrubber so that the oil could be kept warm enough to flow. The next time a unit was installed on this system, a home made scrubber was buried so that the temperature of the oil stayed up. This was also a satisfactory solution to the problem.

Another difference in handling natural and casinghead gas is in sizing the compressors required. In a natural gas field, one must size for the maximum production available from the field, but in casinghead operations one can stagger his production so that his units run practically all the time rather than just 8 days and his compressor horsepower requirements are much less unless he is also using these compressors for gas lift operations. One of the principal safeguard differences which must be taken into account is brought about by gas lift operations. In the event of a blizzard or other weather which would prevent one from reaching a unit which is in operation, he must have an automatic shut down of some sort which will prevent them from running long enough to overflow the tank batteries.

One final problem which may occur in handling either natural or casinghead gas, but which comes up more often handling casinghead is the problem of sour gas. If one takes proper precautions in material selection, he will encounter very little compressor trouble but can meet plenty of trouble in the engines. The way to handle this problem is to raise the operating temperature of the engine to such a point that the acid gas-water mixture cannot condense out and cause trouble. In our opinion, the best way to accomplish this is with embullient or boiling point cooling systems. They have been used in many places and they work well, but men who have operated engines for years with normal cooling systems have a tendency to blame all their engine troubles on the new cooling system unless one waits until he has problems that he cannot handle and then change a system over to solve his problems.

SUMMARY

Field compression of natural and casinghead gas is generally accomplished with packaged reciprocating compressors which are remotely located and operate unattended. Therefore, special consideration should be given to the selection of these units and their accessory equipment. Also the maintenance and operation aspects are quite different from larger, more permanent installations.

A packaged compressor unit properly sized, selected, equipped and maintained is the economic answer to moving natural and casinghead gas in the field. However, no conclusions have been reached about what type of equipment is best for all installations, much less what manufacturers equipment is best. There are numerous makes and types which have some good points going for them and some bad points. It is up to each individual to decide which points are the most important to his operations.