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TRAPS FOR SAVING GAS AT OIL WELLS

BY

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CONTENTS.

	Page.
Definitions of terms used.....	5
Introduction	5
Summary of advantages gained by use of gas traps.....	5
General principle involved in gas-trap construction.....	6
Acknowledgments	6
Loss of oil and gas during production.....	7
Types of traps.....	9
Upright cylindrical traps.....	10
Traps without moving parts.....	10
Traps with automatic outflow valves.....	13
Horizontal tubular traps.....	19
Special traps.....	23
Scharpenberg trap.....	23
McLaughlin low-pressure trap.....	25
Effect upon oil production.....	27
Effect upon oil and gas.....	28
Traps under pressure.....	29
Traps under vacuum.....	30
Utilization of the gas.....	30
Publications on petroleum technology.....	32

ILLUSTRATIONS.

	Page.
PLATE I. A, Baker trap equipped to handle production of several wells; B, Starke trap and connections.....	16
II. McLaughlin low-pressure trap.....	24
III. A, Fuqua trap; B, McLaughlin trap, showing spring suspen- sion.....	26
FIGURE 1. Early form of trap.....	8
2. Trap made of casing nipple placed upright in oil tank.....	9
3. Simple trap constructed of pipe.....	10
4. Simple trap provided with water drip.....	11
5. Pipe trap often used for flowing wells.....	11
6. Oil well low-pressure trap.....	12
7. Tico trap.....	12
8. Oil well high-pressure trap.....	13
9. Baker trap.....	14
10. Washington trap.....	15
11. Trap described by A. B. Thompson.....	16
12. Trumble trap.....	18
13. Starke trap.....	20
14. Bell trap.....	22
15. Scharpenberg trap.....	24
16. McLaughlin high-pressure trap.....	26

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By W. R. HAMILTON.

DEFINITIONS OF TERMS USED.

In this paper the term "gas trap" is used to include all devices for separating and saving the gas from the flow and lead lines of producing oil wells. The terms "gas separator" and "gas tank" are also in common use as trade names for many of the marketed devices described in this paper.

INTRODUCTION.

The prevention of fuel waste is now of urgent importance. During the past decade the mechanical and industrial developments of America have made an immense and rapidly increasing market for the more volatile products of petroleum and for natural gas. When these were produced incidentally as troublesome and nearly unsalable by-products, there was little inducement for their conservation. Now, however, the lighter fractions are considered vitally necessary to the welfare of the Nation, and the value of natural gas as an ideal fuel is so universally recognized that the public is interested in seeing that all possible steps are taken to prevent waste. The use of gas traps, though by no means a recent development, is less extensive than it should be. In line with the endeavor of the Bureau of Mines to aid the producer in every possible way to get the maximum return for his production, this paper is printed to call the attention of oil operators to the fact that many of them should use gas traps. The writer does not attempt to justify the prevention of waste of natural resources; the wisdom of that policy is universally recognized. It is only necessary to remind the producer that the gas and vapors accompanying his oil are extremely valuable and are lost forever if they are not entrapped as soon as produced. Furthermore, the gas trap has other important advantages.

SUMMARY OF ADVANTAGES GAINED BY USE OF GAS TRAPS.

Traps are used under varying conditions of pressure, from vacuum to a pressure above atmospheric. The principal advantages obtained

by the use of traps under vacuum, but not under pressure, are as follows:

1. Increased gasoline content of the gas.
2. Elimination of a part of the storage losses.

When the gas is taken under pressure the advantages gained, which are not obtained when operating under vacuum, are:

1. Decreased tendency of the well to produce sand.
2. Decreased trouble from collapsed casing.
3. Decreased tendency of oil and water to emulsify.
4. Increased gasoline content of oil shipped.
5. Removal of vapors from gas and improvement of gas for transportation long distances in pipe lines.

With either vacuum or pressure traps, or with traps working at atmospheric pressure, the operator gains the following benefits:

1. Increased quantity of gas available for use or sale, hence decreased consumption of other fuels.
2. Minimized danger from fires.
3. Decreased loss of the lighter fractions of the oil.

As gas once lost is gone forever, any one of the above advantages should be enough to cause the universal use of gas traps.

GENERAL PRINCIPLE INVOLVED IN GAS-TRAP CONSTRUCTION.

The basic principle of gas-trap construction is simple. The mixture of oil and gas is allowed to flow through a chamber large enough to reduce the velocity of the mixture to the point at which the oil and the gas tend to separate. The gas, seeking the top of the chamber, is drawn off free of oil; the oil is drawn off at a lower point and the escape of the gas through the oil discharge opening is prevented. Traps have been constructed to meet a variety of conditions, and it is safe to say that the gas can be saved from any well that is under control; also, if a trap is properly installed, there should seldom be interference with the production of oil. Not all known traps are mentioned in the descriptions that follow, but it is thought that any condition at a well can be met by one or more of the traps described; also, it is hoped that the description will enable the operator to choose one that will be suited to his particular need.

ACKNOWLEDGMENTS.

Many of the notes upon which this paper is based were gathered during the year 1915 by Mr. W. M. Welch, of Tulsa, Okla., who, as gas engineer of the Bureau of Mines, began the preparation of this paper. Owing to the severance of his connection with the bureau, he was unable to complete the work. The writer acknowledges his indebtedness to Mr. Welch for suggestions and other aid, and is espe-

cially indebted to Messrs. W. A. Williams, of Bartlesville, Okla., formerly chief petroleum technologist of the Bureau of Mines; Chester Naramore, the present chief petroleum technologist of the bureau; and to two operators who have given especial attention to the saving of gas from flowing oil wells, Messrs. A. C. McLaughlin, of San Francisco, Cal., and P. M. Paine, of Tulsa, Okla. Many other operators in different oil fields have courteously extended information, as have the manufacturers of the traps described.

LOSS OF OIL AND GAS DURING PRODUCTION.

The increase in the production of oil and gas during the past 10 years has been so rapid that many people have lost sight of the fact that it is due solely to the remarkably successful search for new fields. The resulting overproduction and low prices encouraged a great increase in the consumption of petroleum products, and the public has now become so used to an abundance that any lessening of the supply will work a considerable hardship socially and industrially upon the Nation.

New oil fields often reach the zenith of their production soon after their discovery and then decline rapidly. This happens because the so-called "flush" production of a field is made during the time that the oil in the ground contains a maximum of dissolved gas which aids its movement to the wells. During this period the production of gas reaches its maximum and the quality of the oil is at its best. Because of the effort to increase the oil production and to take care of it, the gas is usually wasted. When new wells are brought in the jubilant operator may forget that his product is irreplaceable, that he, unlike a tiller of the soil, does not gather an annual harvest. In the early life of a field waste of gas is more serious than waste of oil. The highest rate of production and the major part of the production of both oil and gas are obtained in the infancy of the well, but more so with gas than with oil, as gas is vagrant by nature, and is difficult to keep. Unfortunately, it is all too common to see a new well flowing under great gas pressure into a sump or tank and filling the surrounding air with so much vapor that there is continual danger of fire. Later, when the production of the same well has fallen to moderate proportions, the operator usually conserves and utilizes the remains of the asset that he formerly wasted.

Oil producing wells are of many types, and conditions often differ in the different parts of the same field. Wells may require pumping or they may flow; they may produce steadily or by "heads"; they may produce clean oil or varying quantities of sand with the oil; they may produce light oil or heavy oil; they may produce oil free from water or oil that contains emulsified water; they may produce oil practically free from gas or immense quantities of gas with lit-

the oil. When unrestricted, wells sometimes flow with such force as to destroy the casing either by attrition or by collapse.

An oil well that does not produce appreciable quantities of gas with the oil, especially during its early life, is an exception. When the oil and gas are under high pressure in the underground reservoir, much of the gas is dissolved in the oil. After the initial pressure has been relieved by the well, the dissolved gas tends to expand and maintain pressure in the well. In time, as gas is constantly

FIGURE 1.—Early form of trap: *a*, gas outlet; *b*, oil inlet; *c*, oil outlet; *d*, gooseneck; *e*, barrel; *f*, tank.

which allows the gas to escape and carry with it quantities of oil held in suspension, and (2) the evaporation caused by the spray of oil. If a water spray is an efficient evaporative device, the evaporation loss from the spray from a flowing well caused by the release of a pressure of 500 pounds or more per square inch must be tremendous. The oil saved from a well flowing unrestrained into the air is, therefore, heavier than the oil produced by the same well under control. The loss from evaporation alone in a wildly flowing well producing oil of Cushing grade will probably exceed 25 per cent during the time of expulsion; when a well flows into an open sump the loss will probably exceed 10 per cent. This does not

escaping with the oil, the expansive force of the gas becomes too small to cause the well to flow, but aids in the movement of the oil through the sand to the well when it is pumped. As the pressure in the oil sand decreases, the proportion of heavy hydrocarbon vapors in the gas becomes greater; hence, although the quantity of gas produced by a flowing well may greatly exceed that produced by a small pumping well, the latter will usually have the greater density.

When wells flow openly into the air or into a sump, a serious loss of oil results. The loss is from two causes: (1) The sudden release of pressure,

cover losses in handling and storage. The gas, of course, is wasted. Not only do the so-called "dry" gases escape, but during their rapid exit from solution in the oil they carry away much of the lighter oil fractions as vapor. Hence the escaping gas is often highly saturated, and its gasoline content entails a heavy loss. Such a gas would be much higher in heat units than a dry natural gas. With the present demand both for its recoverable liquid products and for the residual gas for fuel purposes, the loss of gas from wells of this type is one of the serious losses of the oil industry.

At pumping wells producing a few gallons a day the losses seem insignificant by comparison. However, the average small well producing light oil produces also enough gas to justify saving it. Where no provision is made to save the vapors or to prevent splashing or spraying the operator suffers a considerable loss.

TYPES OF TRAPS.

Gas traps are built in many forms. The basic idea is to arrest the speed of flow in a chamber that separates the gas and oil,

and to take the gas off from the top. One of the earliest gas traps on record was used on Oil Creek, Pa., about the year 1865. A barrel was set upon the top of a tank as shown in figure 1. The oil and gas entered the top of the barrel through one bung, and the gas escaped through another at the top. The oil flowed out the bottom through a U-tube which provided an oil seal and prevented the escape of gas. This early trap, though primitive, embodies the basic principle of gas-trap construction. Other traps are modifications to provide for special conditions.

Traps are described herein which have been used on all kinds of wells from those producing a few gallons of clean oil daily while a vacuum is maintained on the trap, to those producing daily several thousand barrels of oil carrying much sand and several million cubic

FIGURE 2.—Trap made of casing nipple placed upright in oil tank: *a*, 12½-inch pipe; *b*, oil inlet; *c*, gas outlet; *d*, oil outlet; *e*, tank.

feet of gas, under pressures of several hundred pounds per square inch. The type of trap depends on the use that is to be made of the gas. If gasoline is to be produced from the gas by compression or other methods, the pressure on the trap is kept as low as possible. If such use is not to be made of the gas, the production and quality

of the oil will be improved by taking the gas off at as high a pressure as possible.

Though the classification is not wholly satisfactory, traps might be grouped in the three types, upright cylindrical, horizontal tubular, and special. Those of the first type are principally used on wells of small capacity. The second type is especially used for large wells of the gusher type. Traps of the third type are used under certain special conditions.

UPRIGHT CYLINDRICAL TRAPS.

TRAPS WITHOUT MOVING PARTS.

An early form of gas trap is shown in figure 2. The cylinder *a* is merely a casing nipple on the upper end of which is screwed a cap. The nipple stands upright inside the oil tank. The oil enters at *b* and the gas is led off at *c*. As the only seal consists of the oil in the tank surrounding the trap, evidently this trap may be used only under very small pressures. The trap is automatic, and it can not fill up and flow oil into the gas line.

Another of the earlier forms and one of the simplest is shown in figure 3. The oil enters through the pipe *a* and passes from the trap through the gooseneck *b* and is finally discharged at *d*. The gas passes out at *c*. Traps of this type are made of 8 or 10 inch casing and are usually three joints or about 60 feet in length with a gooseneck of about 30 feet. Ordinarily such traps are placed

FIGURE 3.—Simple trap constructed of pipe: *a*, oil inlet; *b*, gooseneck; *c*, gas outlet; *d*, oil outlet.

upright and are supported by the derrick, although on a hillside they may be built on an incline and rest upon the ground. The pressure will be governed by the height of the gooseneck *b*. Traps of this type have been used both on flowing and on pumping wells.

A third simple form of trap, that can be used under a low pressure or a slight vacuum and is well adapted for wells making a small quantity of water with the oil, is shown in figure 4. Oil enters through the side of the trap at *a* and drains out at *b*. The gas leaves the trap at *c*, and the oil seal in the gooseneck in the pipe *b* keeps gas from escaping with the oil. The pressures per-

FIGURE 4.—Simple trap provided with water drip: *a*, oil inlet; *b*, oil outlet; *c*, gas outlet; *d*, drip.

FIGURE 5.—Pipe trap often used for flowing wells: *a*, oil inlet, 2-inch pipe; *b*, gas outlet, 2-inch pipe; *c*, oil outlet, 4-inch pipe; *d*, gas valve; *e*, oil valve; *f*, 2-inch vertical pipe; *g*, 4-inch vertical pipe.

missible are limited only by the strength of the shell and by the height of the oil seal. Traps of this design have been used under a vacuum of 20 inches of mercury. Small quantities of water, if not in an emulsified form, can be trapped out by means of the drip *d*.

A pipe trap commonly used for flowing wells is shown in figure 5. This trap is made of pipe and fittings and is easily and quickly constructed. The oil flows in at the side of the vertical pipe and near its bottom. The 4-inch pipe, *g*, is 40 to 60 feet high and acts as a velocity arrester as the oil rises above the level of the inlet pipe *a* when flowing from the well at high velocity. The oil escapes from the trap at the bottom, and the height of the oil in

the trap governs the velocity of outflow. The manipulation of the valves *d* and *e* by the operator controls the height. The trap gives entire satisfaction with wells of comparatively steady output, but is difficult to regulate with wells that flow intermittently. This trap has been built to handle the oil from wells of large dimensions. Such traps will handle with little trouble oil containing a large percentage of sand, and they can be operated at any pressure desired.

The Fuqua trap, shown in Plate III, *A* (p. 26), an elaboration of the simple trap just described, has been used on a well that produced about 20,000 barrels of oil a day, with a high proportion of sand, and several million cubic feet of

FIGURE 6.—Oilwell low-pressure trap: *a*, oil inlet; *b*, gas outlet; *c*, oil outlet; *d*, ball float.

FIGURE 7.—Tico trap: *a*, tank; *b*, oil inlets; *c*, gas outlet; *d*, oil outlet; *e*, float; *f*, stem; *g*, float valve; *h*, valve body; *i*, valve stem handle. Gas trap patented.

gas. As the object of the installation was to control the gas so as to pipe it to a point remote from fire danger, the quantity of gas produced was not measured.

The oil and gas entered through a horizontal 6-inch flow line which was connected to 12½-inch vertical pipes at a height of about 40 feet above the ground. These vertical pipes were about 90 feet long. The oil and sand flowed out from the bottom, and the gas was taken from the top. Both gas and oil outflow lines were regulated by means of pressure-controlling valves. This trap successfully handled the production of the well which, owing to the large quantities of sand in the oil, presented a particularly difficult problem.

TRAPS WITH AUTOMATIC OUTFLOW VALVES.

Upright cylindrical traps are often equipped with an outflow valve which operates mechanically and controls the amount of oil within the trap. Such traps are of two general forms, those actuated

FIGURE 8.—Oilwell high-pressure trap: *a*, tank; *b*, oil inlets; *c*, gas outlet; *d*, oil outlet; *e*, equalizing pipe; *f*, float; *g*, guide; *h*, bracket from float to valve; *i*, lever and counterbalance; *j*, adjustment for travel of float; *k*, adjustment for travel of valve seat; *l*, feed to float.

by an inside float,^a and those actuated by the weight of the oil.

The Oilwell low-pressure trap, shown in figure 6, is one of the simpler forms of automatic traps. Four openings, *a*, are provided in the top for the inlet of the oil. The gas escapes at *b*, and the oil,

FIGURE 9.—Baker trap: *a*, oil inlet; *b*, oil outlet; *c*, check valve; *d*, gas outlet; *e*, wooden float, 6 by 12 by 24 inches; *f*, emergency check valve, 2 inches in diameter; *g*, gage glass; *h*, handhole; *i*, clean-out; *j*, valve stem supporting float; *k*, valve-stem guide.

through the rotary valve *c*. The ball float *d* controls the height of oil in the chamber. This trap works satisfactorily on wells making clean light oil and has been used with gas pressures ranging up to 50 pounds per square inch.

^a Paine, P. M., and Stroud, B. K., Oil production methods, with a chapter on accounting systems, by W. F. and W. B. Sampson, 1913, pp. 171-172.

The Tico trap is shown in figure 7. The oil enters through the four openings *b*, and is deflected against the sides of the trap to separate the gas and to lessen the effect of turbulence on the float. The outlet for the gas is at *c*. The oil leaves the trap through the valve *g*, which

FIGURE 10.—Washington trap: *a*, oil inlet; *b*, oil outlet; *c*, balanced float valve; *d*, gas outlet; *e*, emergency float valve; *f*, overflow; *g*, safety valve; *h*, oil tank patented.

the float *e* opens and closes. The float is of the open-bottom type, and is supported on an openwork spider on the stem *f*. The float will retain its shape under all pressures, as the internal and external pressures are the same. This open construction can not be used under a

high vacuum, but the valve can be used with any gage pressure from zero to the pressure the shell is built to stand.

FIGURE 11.—Trap described by A. B. Thompson: *a*, oil inlet; *b*, gas outlet; *c*, oil outlet.

The Oilwell high-pressure trap, shown in figure 8, is one of the traps most generally used. This trap works by gravity. An upper

A. BAKER TRAP EQUIPPED TO HANDLE PRODUCTION OF SEVERAL WELLS.

B. STARKE TRAP AND CONNECTIONS.

and a lower spring pipe *e* which enter, respectively, the top and bottom of the float, connect the outside float *f* with the interior of the tank *a*. A guide *g* which keeps the float in proper position at all times holds the upper pipe in place. This guide, or bracket, also carries the counterpoise lever that keeps the float in balance and makes its operation automatic. The trap acts as follows:

The oil, when admitted to the trap through the top openings *b*, rises and part of it passes through the lower pipe *e* into the float *f*. When enough oil has entered the float to overcome the weight of the counterpoise *i* the float lowers by gravity and opens the valve that is connected to its side with a bracket and lock nuts. The opening of the valve permits the oil to discharge through *d* until lowered to a point where the counterpoise weight overcomes the weight of oil in the float. The float then rises to its original position, taking with it the valve, which is thus closed. This action is intermittent and is repeated so long as oil is permitted to enter the top of the trap. The trap is entirely automatic in its action, requiring no attention, except to see that the counterpoise weight and the valve stem are properly adjusted. The valve control is independent of pressure, and the device works equally well under vacuum or high pressure. The limit of pressures and capacities depends on the strength of material in the shell of the trap. This trap works satisfactorily with light oils, but would be less satisfactory with the more viscous oils, as the oil must flow rapidly through the spring pipe to operate the valve with reasonable promptness.

The Baker trap, shown in figure 9, is adaptable for moderate pressure or a high vacuum. The oil enters the trap at *a* and is deflected downward. It flows unrestricted through the outflow pipe *b*. The height *x* of the trap above the discharge end of the pipe *b* must be sufficient to overcome the loss of head due to a vacuum in the trap. To prevent the suction drawing air back through the oil-discharge pipe, a horizontal check valve *c* is inserted in the line. Gas leaves the trap at *d*. To prevent oil overflowing the trap and entering the gas line, in event of an unusual rush of oil the float *e* closes the valve *f* and pressure builds up in the trap, accelerating the escape of the oil. In the figure, A shows the trap in plan and elevation, B shows the detail of the check valve and float, and C the general arrangement of the trap and pipe connections for use under vacuum. In C, 1 represents the well, 2 the gas trap, and 3 the tank.

Plate I, A, shows a Baker trap installed, and also the method of connecting the oil lines from a number of pumping wells to one trap. The double manifold shown enables the attendant to cut out the oil from an individual well to sample it, or for any other purpose. In this installation the trap worked under a vacuum of about 14 inches of mercury.

The Washington trap is shown in figure 10. This trap is designed for low pressures. The oil, which enters the trap at *a* is discharged at

FIGURE 12.—Trumble trap: *a*, safety valve; *b*, gas outlet; *c*, extra strong pipe; *d*, oil inlet; *e*, pressure gage; *f*, expanding chamber; *g*, gage glass; *h*, balanced float valve; *i*, oil outlet; *j*, settling chamber; *k*, waste discharge for sand and water; *l*, nipple welded to tank.

b through the balanced float valve *c*. The gas is drawn off at *d*. If an unusual rush of oil overtakes the discharge line, the float valve

e closes, and prevents the escape of oil into the gas line. Pressure then builds up within the trap and accelerates the discharge of oil. The safety valve prevents the pressure from rising excessively high, by permitting the oil to discharge through the pipe *f*. This form of trap works well for moderate pressures and for oil free of sand particles.

In figure 11 is shown a trap illustrated and described by Thompson.^a In this trap the large inside float actuates a cock on the discharge line by means of the rocker above. This trap is suitable for low pressures and for wells producing light oil and no sand. A gate valve in place of the cock would be an improvement.

The Trumble trap, shown in figure 12, can be used either under a vacuum or under any pressure the material will stand. It has been used chiefly on flowing wells. It controls the flow of oil from the receiving chamber by means of a float operating through a stuffing box in connection with a balanced valve in the oil line.

The oil and gas are conducted downward through a smaller pipe inside the neck of the shell. The oil falls to the bottom and the gas, after passing up through the oil, rises through a series of baffles and enters the gas discharge line through a perforated pipe surrounding the oil and gas inlet line. The baffles thoroughly separate the gas and oil. At the request of the manufacturers, the details of construction of these baffles are not shown.

In this trap the sand and water are periodically drawn off at the bottom, the oil flows off at the side through an automatic discharge valve, and the gas, after passing through the oil, escapes at the top. This arrangement presents a satisfactory combination for a well that is not making large quantities of sand and thus does not need to have the sand pocket frequently emptied.

HORIZONTAL TUBULAR TRAPS.

Two types of horizontal tubular traps are rather commonly used in California on gusher wells. Such traps can be quickly and easily made of material usually available about oil wells, and are convenient to install, especially in an emergency. However, as a large proportion of the cost of installation is labor, which has no salvage value, they are used only on large flowing wells.

The Starke^b trap, shown in Plate I, *B*, and in figure 13 is made from pipe and fittings used in the oil fields and can be assembled by the field force. As this trap has no large diameters or flat or conical surfaces, it is particularly adapted to high pressures. It is made of six to eight joints of pipe of relatively large size. At intervals of about four feet, 1-inch risers are tapped into the top

^a Thompson, A. B., Oil field development, 1916, 570-71.

^b News Items, Conservation of oil and gas in California, California Derrick, vol. 7, Sept. 10, 1914, pp. 7-8. Burrell, G. A., Seibert, F. M., and Oberfell, G. G., The condensation of gasoline from natural gas: Bull. 88, Bureau of Mines, 1915, p. 99.

FIGURE 13.—Starke trap: 1, 2, 3, 4, 4-inch gate valves; 5 to 11, 1-inch risers; 12, 2-inch blow-off; 13, outlet to gas main; 14, 10-inch casing; 15, 6 $\frac{1}{4}$ -inch casing; 16, 15 $\frac{1}{2}$ -inch casing; 17, 18, 2-inch gate valves; 19, pressure gage; 20, gage glass; 21, stopcock to regulate oil flow; 22, 1-inch by-pass; 23, oil outlet; 24, oil inlet; 25, 6-inch gate valve. Gas trap patented.

of the large pipe. These risers are shaped like an inverted U bend and are connected with the top of a second horizontal pipe several sizes smaller, 8 to 10 inches in diameter, and each riser is fitted with a valve or stopcock. This second horizontal pipe is again connected at one end to a larger pipe also lying level, that acts as a reservoir or receiver, and gives off the gas through a riser of suitable size.

The oil and gas flowing together enter the large pipe or separating chamber through the flow line from the well. The first joint of the large pipe is not tapped with risers, acting more strictly as a separating chamber. As the mixture of oil and gas enters this pipe, the oil settles to the bottom and the gas is carried along the top and out through the risers to the second horizontal pipe. Enough of these risers are used so that their aggregate cross section considerably exceeds the area of the flow line from the well. The oil and the gas separate and become quiet, thus there is no tendency to carry oil over with the gas through the risers from an effect similar to "priming" in a boiler. The oil that collects in the bottom of the large pipe is run off through a stopcock at the end opposite the one through which it enters. The level of the oil in this pipe is indicated by a gage glass and, even when a well is flowing large quantities of oil, remains quiet with only a slight pulsating effect, showing that agitation of the oil and gas has ceased. The stopcock is set to deliver approximately the same quantity of oil that the well is producing.

A pocket for collecting sand can be inserted in the trap, preferably near the point where the oil is taken off, and can be so arranged that the sand may be removed at convenience or when the pocket is filled.

In installing the Starke trap on wells equipped with reducing nipples the more recent practice is to do away with the nipple at the mouth of the well, so that the full backed-up pressure of the well is on the trap, and have the flow nipple, with its restricted opening, beyond the trap. Under these conditions the oil and gas can be separated under pressure as high as 500 pounds, or as high as may be desired, as the control is on the discharge side of the trap away from the well, and there is no throttling between the well and the trap.

The pressure under which the Starke trap can be used is only limited by the bursting strength of the largest size of pipe, and by the strength of the fittings used. As 15½-inch screw pipe that will stand a pressure of 800 to 1,000 pounds per square inch and fittings tested to 1,500 pounds are commonly at hand, the limit of pressure on the trap is determined by the well rather than by the strength of the trap. In wells of the gusher variety as originally brought in both in the Midway and in the Coyote Hills districts of southern California, 400 or 500 pound pressure upon the well was frequently necessary. By placing the trap in direct connection with the well, that is, without any intervening pressure-controlling valve, a gas free of oil particles or unabsorbed gasoline is delivered at the backed-up

FIGURE 14.—Bell trap: 1, 4-inch inlet from well; 2, 4-inch gate valve, extra heavy; 3, 4-inch plug; 4, by-pass to sump; 5, 6-inch butterfly valve; 6, oil outlet to tank; 7, 1-inch equalizer; 8, 4-inch pressure valve; 9, outlet to gas main; 10, safety valve; 11, stuffing box; 12, float, 10 inches in diameter and 24 inches long; 13, 12½-inch casing; 14, ¼ by 2-inch bar.

well pressure and is therefore ready to be introduced without compression into a high-pressure transportation system.

This trap has no automatic control, but as it is only used on wells of unusually large production a man should be in constant attendance.

In the Bell trap, which is shown in figure 14, the mixture of oil and gas from the well enters the trap proper through a flow nipple for restricting the free flow from the well. Through this nipple the oil and gas pass into a 6-inch pipe, about 175 feet long, of which the end is perforated for about 70 feet. Six-inch perforated pipe, the same as that used on California wells, is used for this purpose. This 6-inch pipe is within a pipe of larger size, about $12\frac{1}{2}$ inches in diameter and 240 feet long, and the two are connected by means of a 4 by 6 inch heavy steel bushing and swage nipple. A tee with a suitable size outlet is connected in the outer line at the oil inlet end to carry off the gas.

The $12\frac{1}{2}$ -inch pipe is laid on a gradient ranging from not less than 3 per cent to as much as 8 or 10 per cent, with the inlet end highest. At the lower end of the $12\frac{1}{2}$ -inch pipe is a 6-inch swage nipple, to which a riser enlarged to 12 inches is connected. In this riser is a wooden float, connected through a rod and stuffing box to a butterfly valve, which controls the flow of oil from the trap, thus making it automatic. The float is so situated as to maintain the oil level in the inclined pipe at such a height that the end of the perforated 6-inch pipe, within the $12\frac{1}{2}$ -inch pipe, is submerged about 20 feet of its length.

The mixture of oil and gas enters the $12\frac{1}{2}$ -inch pipe or receiving chamber through the flow nipple and 6-inch pipe. A large part of the gas and some of the oil leave the 6-inch pipe through the perforations; the balance passes out at the end. The oil settles in the 12-inch pipe. The float and butterfly valve control its level and regulate its flow. As the gas rises through and above the oil, its direction of flow is reversed and it passes out at the intake end of the $12\frac{1}{2}$ -inch pipe through the side opening of the tee mentioned.

The Bell trap has been used on wells producing several thousand barrels of oil and many million cubic feet of gas a day. The butterfly valve does not shut off the flow entirely, as there is enough clearance around the valve to prevent any danger of its sticking from sand that may lodge about it. As a consequence this trap has satisfactorily handled oils that carry much sand in suspension.

SPECIAL TRAPS.

SCHARPENBERG TRAP.

The Scharpenberg trap (fig. 15) is an ingenious use of the principle employed in the construction of gas holders. The trap holds a

FIGURE 15.—Scharpenberg trap: 1, annular tank; 2, cylindrical tank; 3, standpipe for entering oil; 4, oil outlet; 5, gas outlet pipe; 6, plate; 7, top of cylindrical tank; 8, relief valve; 9, excelsior screen; 10, gas outlet; 11, oil inlet. Gas trap patented.

McLAUGHLIN LOW-PRESSURE TRAP.

a, Valve; *b*, valve seat; *c*, trap shell; *d*, beam; *e*, counterweight, made of old casing filled with scrap iron; *f*, support; *g*, pipe from gas line; *h*, oil line from well; *i*, iron guide for beam; *j*, gas outlet; *k*, hose clamp; *l*, discharge to sump; *m*, nipple; *n*, oil inlet; *o*, hose; *q*, flanged union; *r*, safety valve; *s*, emergency stop valve; *t*, hold-down rods; *u*, old $\frac{1}{2}$ -inch sand line; *v*, vacuum attachment; *L*, length of attachment. Gas trap patented.

constant pressure on the well and on the gas line. The annular tank 1 has two shells that form a water seal between them. A second circular tank 2 moves vertically between the two shells 1. A deflector in the oil-inlet pipe 3 throws the oil downward. The oil outlet 4 is through an oil seal, the upper end of which is open to the atmosphere to prevent syphoning. The gas-outlet pipe 5 is in the center of the tank 1 and extends slightly higher than the top of the tank. A layer of excelsior 9, supported upon wire screens, separates any fine particles of oil which might be carried in suspension by the gas.

When gas is being taken from the trap faster than it is produced by the wells, plate 6 seats itself upon top of pipe 5, closes it, and prevents a vacuum in the trap which might draw air through the oil and water seals. When gas is produced faster than it is taken away, the relief valve 8 prevents the blowing out of the oil and water seals when the floating tank has reached its upper limit of travel. This trap has been built about ten feet in diameter and the tanks about ten feet in height, and is best adapted for pressures of from one ounce to one pound per square inch. Besides the advantage of maintaining a constant pressure on the well and gas delivery line, the trap can be used conveniently for measuring gas.

M'LAUGHLIN LOW-PRESSURE TRAP.

The McLaughlin^a low-pressure trap, shown in Plate II, is a cylindrical shell, supported by a framework or by springs in such a way that the weight of the shell is balanced. The automatic action depends upon the movement up and down of the entire shell and its contents. The inlet pipe enters the bottom of the trap and is stationary; to this pipe is attached the annular ring, forming the discharge valve. The line for carrying off the dry gas is connected to the top of the shell, preferably by a flexible connection, to permit free vertical movement of the trap.

At the bottom of the shell is an annular valve which is opened and closed by the vertical movement of the shell. The oil, gas, and sand enter the trap through the line *h* from the well. On this line is fitted a cast-iron valve *a*. This valve engages a cast-iron seat *b*, which forms a part of the trap shell *c*. The inlet pipe and the valve *a* are stationary, but the trap shell *c* and the valve seat *b* move up and down to close and open the valve. The trap shell *c* is suspended on one end of the beam *d*, and the counterweight *e* is sus-

^a For descriptions of McLaughlin trap, see Paine, P. M., and Stroud, B. K., Oil production methods, 1913, pp. 171-172; Oil Age, Saving the gas, vol. 9, Mar. 27, 1914, pp. 5-6; Beckley, R. E., Theory of action of McLaughlin automatic gas trap, Bessemer Monthly, October, 1914; Dykema, W. P., The recovery of natural gas by refrigeration and compression, Bull. 151, Bureau of Mines, 1918, p. 23.

pended from the opposite end of the beam. After the length of the beam arms have been established, the weight of counterbalance needed is found by trial. The oil, gas, and sand flow into the trap through the vertical pipe *n* and are deflected downward by the de-

FIGURE 16.—McLaughlin high-pressure trap: *a*, gas outlet, made of 4-inch hose; *b*, baffles; *c*, oil and gas inlet, 4-inch hose; *e*, oil outlet, 3-inch pipe; *f*, counterweight, equal to weight of empty trap, is filled with old iron gas trap patented.

flector on the upper end of this pipe. While this trap is empty, or the counterweight is heavier than the contents of the trap, the counterweight keeps the valve seat *b* on the valve *a*. As soon as enough oil and sand, if sand is present, has been admitted to the

A. FUQUA TRAP.

B. McLAUGHLIN TRAP (LATEST TYPE), SHOW-
ING SPRING SUSPENSION.

trap to overbalance the counterweight, the shell moves downward. This opens the valve and allows the oil and sand to discharge into the wooden trough until the counterweight again overbalances the weight of the shell and its contents and closes the valve. The position of the entire unit may be so maintained that the oil will flow constantly and almost uniformly from the trap, and the discharge valve will open only enough to allow the passage through it of the amount of oil produced.

The gas separates from the oil in the shell, rises through baffles, and passes out from the trap through the top connection into the pipe line. As the oil flows from the trap quietly and without the churning that takes place when oil highly charged with gas flows freely from a well, much of the lighter constituents or vapors is held in the oil that would otherwise be lost.

The action of the trap is positive, as the operation of the valve that controls the flow depends upon the weight of a considerable quantity of oil. This valve is placed at the bottom of the receiving cylinder and allows any sand or water coming from the well to pass out with the oil. The oil after leaving the trap is passed through boxes to collect the sand, which is drawn off or shoveled away as it accumulates. Any water present is drawn off from the storage tank. The McLaughlin trap can handle large quantities of sand. The valves are the only parts that are worn by the sand and are easily replaced.

When this trap is used under vacuum, the attachment shown in figure 16 is added. The length L of this attachment depends upon the vacuum, measured in inches of mercury, that is to be maintained on the trap.

Figure 16 shows the McLaughlin high-pressure trap. The action is the same as that of the low-pressure type except that the oil enters at the side of the trap through a hose. This discharge valve does not connect with the inlet pipe, but opens when the trap descends; the valve stem protrudes below the trap and comes in contact with a seat provided for the purpose. The oil discharges into a pipe line when the well makes no sand. In the latest installations the beam and counterbalance are done away with; springs support the trap as shown in Plate III, *B*. The tension of the springs is adjusted so that the oil is kept at the proper height in the trap.

EFFECT UPON OIL PRODUCTION.

In many districts where gas traps are not used, the idea is common that gas traps put back pressure on the well and injure the oil production. The pressure within the trap depends upon the pressure in the pipe line to which the gas is delivered after passing through the trap. Should back pressure on the well seriously affect the yield

of oil, and should the only practical use of the gas from a large well require that it be delivered into a pressure line, a gas pump would be necessary to reduce the pressure at the discharge of the trap. For purposes of supplying gas to near-by points, the line pressure required should not be great enough to have any marked effect upon the well. Reliable data are not at hand as to the effect of such pressure against wells of the Mid-Continent or Eastern fields. In many wells in the Midway-Sunset and Fullerton fields of California the rate of production has been increased by the maintenance of pressures of 50 to 200 pounds at the well head. This is especially true as regards wells that produce sand with the oil. Many such wells, if allowed to flow without restraint, flow by "heads" and during the time between eruptions of oil, blow great quantities of gas. The back pressure causes the well to flow steadily, and the amount of sand is greatly lessened. The effect of back pressure claimed in other fields is probably overestimated.

With wells of moderate capacity it is often possible to increase the production of oil by maintaining a partial vacuum on the well. This is usually done by connecting the suction pipe of the gas pump to the casing head and by keeping a partial vacuum between the casing and the tubing. When a well is being gas pumped in this way, there can be no disadvantage in keeping the lead line under vacuum with a gas trap.

EFFECT UPON OIL AND GAS.

The effect of a trap upon oil and gas will depend somewhat upon its mechanical construction, but mainly upon the pressure under which it is used. The pressure may be atmospheric or zero gage; it may be less than one atmosphere or partial vacuum; or it may be several atmospheres.

When the trap works at or near atmospheric pressure, little change in the oil and gas will take place, and the trap will save all the dry gas and, at the same time, prevent the serious losses of oil that would result did the oil flow freely into a tank or sump. The trap under these conditions acts as a velocity arrester and separating chamber, and any of the vapors of heavier hydrocarbons removed from the oil by the escaping gas will be held in suspension by the gas and become part of it. Such gas may be suitable for gasoline production. Should the oil be light and the well production be large, the gas will often have a cloudy appearance, especially if the oil is warm. This cloudiness is probably largely due to water vapor.

Local conditions determine whether the trap is to be kept at a partial vacuum or at a pronounced pressure. For wells producing a large quantity of oil and several million cubic feet of gas a day a

partial vacuum is usually impracticable. For wells producing moderate quantities of oil and gas, the use of a vacuum is entirely feasible. Many of the traps described in this paper are adaptable for either vacuum or pressure. In certain oil fields the purchasing companies buy oil on the basis of its gravity, paying a higher price for the oils of lower specific gravity. The price varies with the change in gravity measured in degrees Baumé, and is based upon the assumption that the specific gravity shows the gasoline content. In other fields the price paid is the same for any oil regardless of its specific gravity. In the latter fields it pays the producer to increase, if possible, the gasoline content of his gas and then treat it to recover the gasoline. In the former he may gain more by retaining as much of the gasoline in the oil as possible, especially when conditions do not justify the installation of a gasoline plant.

TRAPS UNDER PRESSURE.

Traps under pressure are used chiefly on large flowing wells. In many fields flowing wells if allowed to flow without restriction would produce large quantities of sand, and the casing would soon collapse. In California, the wells usually flow through a restricted opening or reducing nipple to keep back pressure against the oil. This lessened casing troubles and the amount of sand produced, but in many wells an emulsion of water and oil was formed which was difficult to treat. Removal of the reducing nipple between the well and the trap and keeping pressure on the trap prevented emulsion, which seemed to take place during the expulsion of the oil through the opening. The restricted opening, or "bean," as it is locally called, is now often placed in the trap discharge, though the common practice is to place it at the well.

One of the first effects from the use of gas traps noted by operators was that the oil had a lower specific gravity when delivered through a trap under pressure. Also, at many wells when traps were installed an apparent increase in production of oil resulted, or the rate of decline was temporarily arrested. This can be attributed to reduced volatilization losses. Some remarkable improvements in specific gravity have been reported, but it is possible that emulsified water, which is less prominent in oil handled under pressure, interferes with the determination of specific gravity as done in the field. Determinations by the chemists of the Bureau of Mines have demonstrated that with pressures of approximately 50 pounds in the trap, the oil produced has been improved in gravity from 1 to 2.5° B. and the amount of light hydrocarbons distilling over at temperatures below 200° C. has been increased as much as 4 per cent. In some wells an increase in the pressure results in deteriorated oil; thus, one well showed a heavier product with the trap at 100 pounds than when the

oil was not under pressure. The oil probably absorbs dry gas at the higher pressure, and on the release of pressure at the outlet of the trap this dissolved gas rapidly escapes and carries off gasoline vapors. The critical pressure for each well can be determined by trial, and it varies from well to well.

TRAPS UNDER VACUUM.

When oil enters a trap kept under partial vacuum the effect is similar to that of spraying oil into the atmosphere, except that in the former instance the most valuable part of the oil is saved and in the latter it is lost. The oil may be expected to lose some of its more volatile constituents, the amount removed depending upon the character of the oil, the pressure on the trap, the temperature, and the amount of agitation to which the oil is subjected while under vacuum. When oil high in gasoline content is held for long periods in storage tanks, the volatilization losses are extremely large. Such loss may be minimized by subjecting the oil to agitation and vacuum as it is produced. The oil will then be poorer and the gas will be richer in the higher hydrocarbons, which can easily be recovered from the gas as gasoline.

Gasoline-plant operators will find such a gas much higher in gasoline content than the so-called "casing-head" gas that is taken from the outside of the tubing. On a certain property where the "casing-head" gas produced 3 gallons of gasoline per 1,000 cubic feet, the "trap" gas produced as much as 10 gallons. Other instances have been reported in which the difference was even more marked. If all wells that produce oil high in the lighter hydrocarbons were equipped with vacuum traps there would be a substantial increase in the gasoline production of the Nation. Therefore, whenever feasible, oil as it is produced should be subjected to vacuum, and the gasoline should be recovered from the gas.

UTILIZATION OF THE GAS.

The gas produced with the oil and separated from it by gas traps often contains vapors of the heavier hydrocarbons in appreciable quantities, especially when separation takes place at low pressure, or under vacuum. When the quantity of gas so produced warrants, the gasoline should be recovered before the gas is used. The recent development of processes for recovering gasoline from natural gas by compression and by absorption has made possible an important addition to the gasoline supply. The steadily increasing demand for gasoline is a serious problem as the supply is gradually diminishing. It has been demonstrated recently that natural gas containing so little gasoline as to make recovery by compression and cooling un-

profitable or impossible, can be treated profitably by absorption.^a The gas so treated, although it has lost a part of its calorific value, is no less desirable for many uses, and is even then higher in heat units than the best artificial gas. Furthermore, when "wet" natural gas is being piped to market, the condensation of gasoline in the pipe lines is a source of constant annoyance. The cost of replacing rubber gaskets, decomposed by the condensed gasoline, is an important item with many pipe lines.

When searching for a market for the treated gas, domestic consumption should always receive first consideration. For such use it is much superior to artificial gas, as artificial gas has a lower thermal efficiency and often contains poisonous gases.

On an oil producing property, the burning of other fuels while gas is going to waste should not be permitted, as oil and other fuels can be stored for future use, whereas gas can not.

At properties equipped with steam engines the waste gas should be used to fire the boilers. As the highest efficiency in the use of gas for power is obtained in internal-combustion engines, the more progressive companies have gas engines for power purposes wherever possible. In industrial plants, gas engines of large capacity are considered highly efficient as prime movers and where a dependable supply exists, no more satisfactory engine could be installed. Natural gas is extensively used in brick, tile, cement, and glass manufacture, and in the Mid-Continent field the smelting of zinc ores with gas fuel is a large industry. These are wasteful methods of utilization and are only justified when the domestic market is well supplied.

A common method of utilizing natural gas, when remote from a more remunerative market, is the manufacture of carbon black. On account of the recent development in rubber-tire manufacture, in which carbon black is used in large amount, the price of that material has so increased as to make its manufacture from natural gas highly remunerative. The industry is most extensive in West Virginia. The process is essentially that of burning gas with an insufficient supply of oxygen, the carbon depositing upon a plate above the flame from which it is subsequently scraped off and conveyed to a bolting machine. After bolting it is packed and is ready for market. As no use is made of the heat produced, the methods now in use are wasteful. Under the present prices carbon black could be manufactured at a profit by much smaller units than the existing plants. Such utilization of natural gas is not to be recommended when there is a market for the gas for domestic purposes, but is preferable to the all too common practice of letting the gas blow to waste.

^a Burrell, G. A., Biddison, P. M., and Oberfell, G. G., The extraction of gasoline from natural gas by absorption methods: Bull. 120, Bureau of Mines, 1917, p. 8.

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