POWER DRILLING RIGS FOR ROTARY OIL WELL DRILLING

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Emsco Derrick & Equipment Co.

Power drilling rigs are playing a very important part in the production of oil all over the world. Among those who have been instrumental in the development of this type of equipment are several Cal Tech Alumni including R. W. Craig '21, Harold Puls '23, Walter Moore '23, B. R. Schabarum '25, Leroy Newcomb '25, Nick D'Arcy '29, Bob Ramey '30, Spencer Long '30, Ed Foss '32, Jim Keeley '31, Bob Gardner '36, Don Blodgett '36, M. W. Hinshaw '36, and S. M. Brose '40.

FIRST POWER UNITS

The conventional power for drilling oil wells has been steam generated in large boilers at the well site, but as early as 1927 the Shell Oil Company was drilling wells with gasoline powered rigs. These early drilling units were powered by single 125-horse power engines and drilled a number of wells in the Poso Creek field. These units saved several thousand dollars per well in drilling cost although they did not receive a hearty reception from the oil industry.

Interest increased in power drilling equipment in 1934 due to improved methods of compounding the power of two internal combustion engines. With information and material available at that time, it was possible to manufacture units recommended for drilling wells to a depth of 5000 feet and having 325 horse power available. These units drilled to 8000 feet on several occasions and filled a great need in export fields. Development kept pace with export demands for several years.

The power drilling rig came into its own in California in 1940 and competed very successfully with steam power with the event of 1000-horse power rigs.

APPLICATIONS FOR POWER RIGS

The development of the power rig from a small unit suitable for specific drilling conditions to the present unit capable of drilling under any condition has been the solution of three major problems: first, a unit requiring a minimum of fuel and water; second, a portable unit which could be broken down into small packages; third, a unit that would compete with steam under all conditions.

An examination of the results obtained with power drilling rigs soon shows why they received such a hearty welcome in export fields where both fuel and machinery had to be transported under exasperating conditions. The internal combustion engine was not subject to that eternal boiler problem of "soft water." Wild cat operations did not require extensive exploration for suitable water nor expensive water treatment plants. It was logical to find some of the early power rigs in operation in Egypt and Persia where water was a prime problem. California installations reveal that water consumption is reduced from 60 barrels per hour for the boilers to 10 gallons per week for the internal combustion engines.

Fuel consumption on internal combustion rigs is only about 10 per cent as great as on steam rigs. This is a major saving when all fuel has to be transported hundreds of miles to remote wild cat locations but it has not been given great consideration in California due to the abundance of natural gas in most fields. Operators now realize that gas consumed under the boilers makes production problems for the future and are giving fuel economy serious thought.

Export operators were also interested in portable units. Power driven rigs can be broken down into packages none of which weigh over 10,000 pounds, whereas steam boilers weigh approximately 30,000 pounds and are very bulky. In local fields modern roads and well equipped trucking companies reduce the demand for readily portable units, but the quick moves made with power outfits appeal to the local operators. In shallow fields the entire power rig can be moved on one truck without disconnecting the engines, reverse gear or drawworks. This saves several hours rig-up time as compared to steam rigs, and as these shallow wells are drilled in from 18 hours to 3 days this is a major saving.

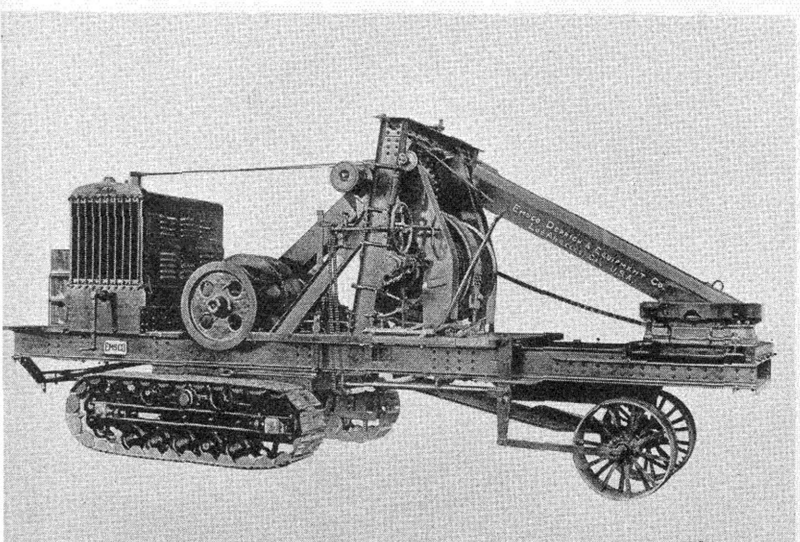
California manufacturers developed for California contractors power drilling rigs that would compete with steam on California deep drilling operations.

PERFORMANCE

The two largest power drilling rigs now known to be operating are in California, both having been placed in operation in 1940. Each rig is powered by three internal combustion engines developing a total of over 1000 horse power. These rigs have both drilled to depths in excess of 9000 feet in from 60 to 70 days, which is equal to or better than steam rigs drilling in the same field for the same operators.

Power has to be applied to three major machines in rotary drilling. The rotary machine is located directly over the hole to be drilled. It rotates the drill pipe which in turn rotates the drill and digs the hole. The slush pump or pumps are located on the ground outside the drilling derrick. The slush pump forces "mud" through the drill pipe, down to the bit, and washes the cuttings from around the bit up the outside of the drill pipe to the surface. The drawworks is the largest

First known rotary drilling rig designed for use with internal combustion engine operated in Poso Creek Field, California.



and heaviest of the three machines and it is located on the drilling floor. It is used to hoist drill pipe out of the hole when the bit is dull and lower the pipe back into the hole when the new bit has been installed. It also controls the weight carried upon the bit while drilling by feeding off the line as the hole is deepened, allowing the drill pipe to descend.

Most power rigs are designed so that the power from the engines can be applied to the rotary machine, slush pumps or drawworks. Some rigs have independent engines to drive the slush pumps. The two 1000-horse power rigs in California have the engines so compounded that the power from one, two, or three engines can be applied to the rotary machine, slush pump or drawworks. In normal drilling operations, one engine will drive the rotary machine, and two engines the slush pumps. All three machines are compounded into the drawworks when hoisting, and the slush pumps and rotary are idle.

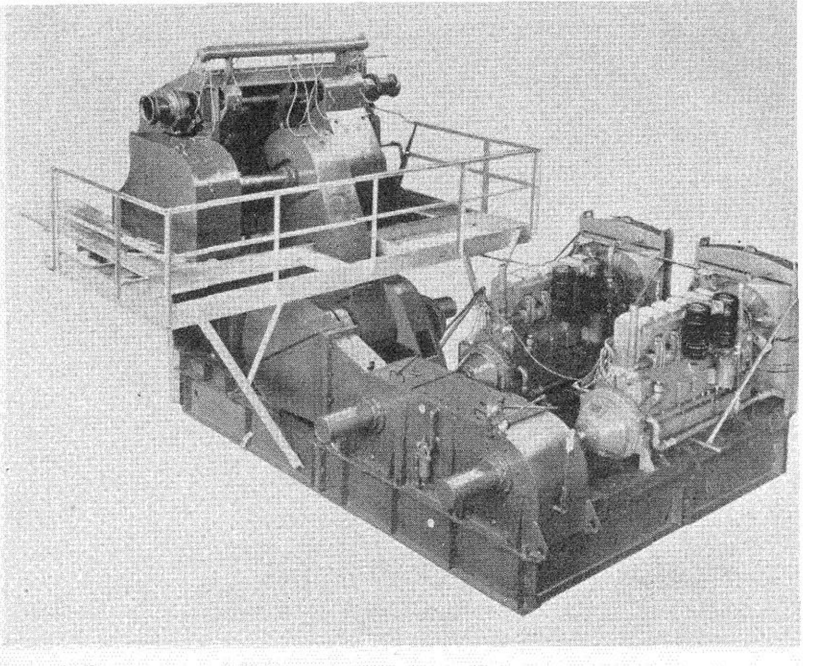
Two smaller power rigs in the Los Angeles basin have superseded steam rigs. These rigs have two 350-horse power engines compounded into the drawworks or rotary machine, with 200-horse power independent drives to each of two slush pumps. The independent slush pump drive allows for a more flexible unit, as the pumps can be placed without regard to the location of the drilling engines. However, this set-up provides less power to the drawworks for hoisting. Both the three-engine 1000-horse power rig and the two-engine 700-horse power rigs are drilling oil wells to depths of 9300 feet and 7500 feet as fast as the steam rigs they superseded.

DESIGN PROBLEMS

In 1927 portable well servicing units were adapted to rotary drilling in an attempt to do a man's work with the boy-size engines then available. These early units were powered by four-cylinder 125-horse power internal combustion engines to allow mounting the entire unit upon a truck and still stay within the 8-foot road limit. The first real advance in power drilling rigs came when two 150-horse power engines were compounded thru chain drives to provide 300 horse power for heavy work. The size of the engines used has steadily increased up to a pair of 450-horse power diesel engines now en route to Colombia, South America.

Numerous problems were encountered in compounding engines. A reverse rotation which cannot be obtained direct from the engines is often necessary on the drawworks and rotary machine. Single engine drives were equipped with a reverse and forward reduction gear in the bell housing of the engine but it did not prove substantial enough for rotary drilling. When two or more engines are compounded, a separate reverse and friction clutch is generally furnished. This clutch provides an instantaneous reverse or forward drive by throwing a lever at the driller's position. The reverse action is obtained through a differential gear and brake that is very efficient. The forward action is obtained through a large frition clutch and the load carried is so large that special friction clutches had to be developed before 1000 horse power could be handled.

Chain used to compound engines gave no end of difficulty on the first jobs but, through added experience, improved design and an increased factor of safety, compounding chain is now virtually trouble-free. On the early drives large (2½") pitch

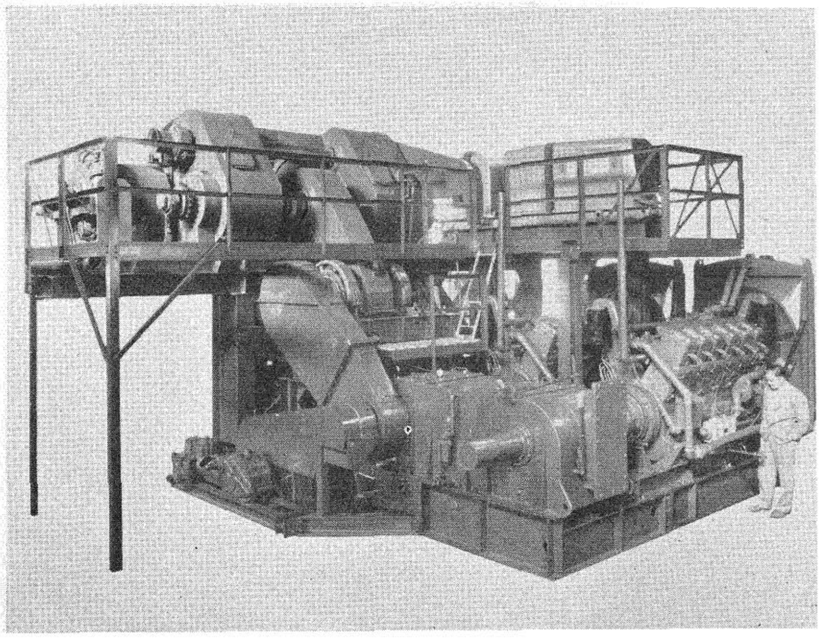


Modern power drilling rig which recently completed a 10,200 ft. well in Saudi, Arabia, equipped with two 225-horsepower Diesel engines and modern chain compounding transmission case.

single chain was used. It was almost impossible to keep oil on this chain, which traveled at between 4000 and 5000 feet per minute when the engines were operating at between 900 and 1000 R. P. M. Also, cotter pins used to fasten side bars were thrown out of the chain at these speeds. Chain speeds were reduced by the use of multiple strand small (1½") pitch chain, and cotter pins were replaced by rivets at an early date, but lubrication continued to be a problem. The latest development in compounding equipment is the oil-tight flood-lubricated compounding transmission. This unit is a large welded case in which all compounding shafts are lined up within very close tolerances with suitable clutches installed on the shafts to provide means of directing the power to the unit or units desired. Each compounding shaft has a drive to a small oil pump which circulates a steady stream of oil onto the chain and all the bearings. The compounding transmission cases hold up to a barrel of oil which is used without loss or waste. An efficient filter insures clean oil at all times. Early chain drives often failed after drilling 5,000 to 10,000 feet, but chain in the new compounding transmissions often lasts for well over 100,000 feet of hole.

Engine manufacturers have assisted in the development of power driven rigs by providing large engines. Although 150-horse power engines were the largest suitable engines in 1927,

Largest known internal combustion engines used on power drilling rig shipped November, 1940, to Colombian Petroleum Co., Colombia.



in 1940 engines developing 350-horse power are available and in frequent use. 450-horse power engines were used on a job shipped from Los Angeles to Colombia in November, 1940.

POWER DRILLING ECONOMICS

The month of November, 1940, has revealed many interesting figures on the performance of power drilling rigs, and all figures point to an increased use of power rigs. One operator reports the operating costs of a boiler plant on a steam rig for one well was $14,000, and for a power rig in the same field was $1,000. The cost on the steam rig included fuel, fireman's wages, and water treating costs; and on the power rig, fuel and mechanic's wages.

A prominent contractor in the Wilmington field reports savings up to $1.00 for each foot of hole drilled with power rigs when compared to steam rigs operating under the same conditions. These wells are being drilled to depths of about 6,000 feet by two engines, each developing 200 horse power.

A contractor running three strings of tools at Coles Levee obtained results shown in the accompanying table while drilling under as nearly identical conditions as it would be possible to obtain.

FIELD DATA ON POWER AND STEAM RIGS

Power —	Power Rig	No. 1 Steam Rig	No. 2 Steam Rig
	3 - 350 H.P. Natural gas internal combustion engines	250-lb. Boiler Plant 14x12 steam engine	350-lb. Boiler Plant 12x12 Steam Engine
Well Depth—Feet			
1st 3 wells	9,025	9,225	9,350
2nd 3 wells	9,100	9,150	8,980
3rd 3 wells	9,190	8,980	9,050
Drilling Time—Days			
1st 3 wells	70	70	76
2nd 3 wells	50	56	57
3rd 3 wells	67	56	62
Gas Consumption—MCF			
1st 3 wells	5,426	39,076	48,882
2nd 3 wells	3,913	36,306	48,962
3rd 3 wells	6,095	38,508	47,083
Water Consumption—Barrels			
1st 3 wells	31,747	108,129	136,973
2nd 3 wells	35,815	93,959	114,550
3rd 3 wells	36,243	98,693	118,541

All of the above drilling times are figured from the day the well was spudded in until the day the liner was set to obtain production. Both the gas and water were metered quantities, and the water included not only that used in the boilers, but all miscellaneous water used on the rig, such as, wash-down water and water in the mud. Drilling in 50 days to 9100 ft. on the second power rig well was the fastest time made in the entire field.

The power rigs show a decided saving in fuel and water consumption in all cases checked and the total drilling time is equal to or better than the wells drilled with steam.

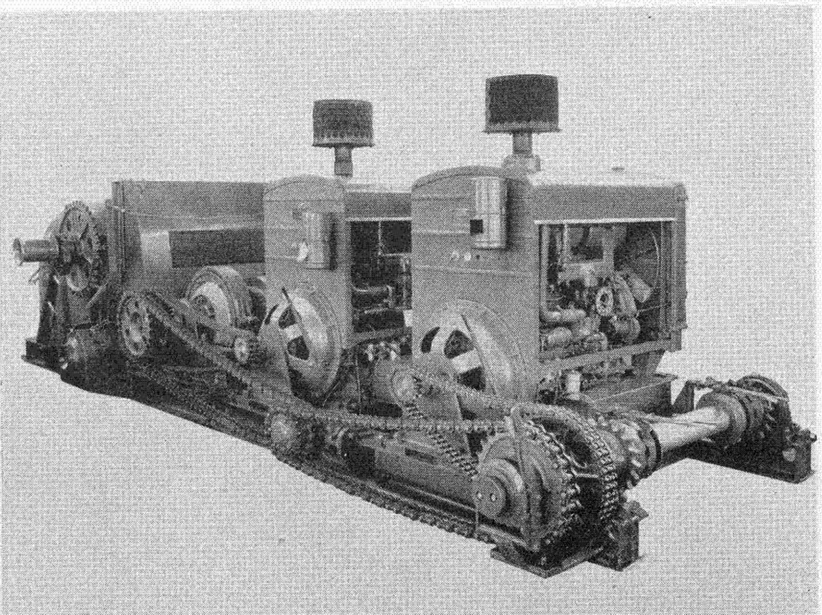
In addition to fuel savings, great savings can often be made through decreased costs in moving, smaller foundations and less grading, less expensive roads due to lighter equipment, and faster knock-down and set-up time when moving from one well to the next.

DEVELOPMENT TRENDS

There are several problems to overcome in power rigs. It is desirable to approach the smooth, even power developed by steam at low speeds, to hold pressure on the slush pump while cementing, to hold a strain on the drilling line while fishing for lost drill pipe, and to provide more power.

Hydraulic couplings, similar to the fluid drive in modern automobiles, are being tried on the latest power rig placed in operation in California. The hydraulic couplings eliminate the solid connection in conventional clutches between the engines and compounding transmission, and act as a cushion or shock absorber between the driven units and the engines. The kinetic energy is low at slow engine speeds and slippage occurs in the coupling when high torques are applied to the drive shaft. No motion is transmitted to the driven shaft when the torque in the driven shaft exceeds that delivered through the fluid in the coupling, and 100 per cent slippage occurs. This is just what is desired to hold pressure in a slush pump while cementing and tension on a line while fishing. It is possible to run the engines for many hours at a speed to develop maximum torque without producing any rotation in the driven shaft by installing a means of cooling the oil in the coupling. Many details have to be worked out in this type of installation, but it gives promise of providing an answer to the problems of smooth power, stalled slush pumps and fishing.

Early dual engine power drilling rig showing complex chain compounding system.



It is likely that 1941 will see power rigs developing 1400 horse power supplied by four engines. This power will be equal to the largest steam rigs in common use and will provide a rig suitable for drilling the deepest wells.

Light power drilling rigs should again become popular due to the development of telescoping and folding drilling masts. It is now possible to mount a 200-horse power engine, drawworks and 90-foot drilling mast on a semi-trailer and meet all California road regulations. This unit is suitable for drilling 4000-foot wells without erecting an expensive derrick. The mast is a very interesting study as it has to be light, compact, easy to erect and tied with a minimum of guys. One 90-foot mast telescopes to 45 feet as the first step in moving, and then folds down over the drawworks and engine. Its height when folded is 13 feet, and it can be erected in less than an hour with power provided on the truck.

CONTRIBUTIONS OF TECH ALUMNI

Harold Puls, '23, Chief Engineer, The Texas Company,

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POWER DRILLING RIGS

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is assisting with the specifications relative to portable drilling masts suitable for drilling to depths of 4000′. Harold has been actively connected with development of portable drilling rigs and has made many valuable recommendations and suggestions for improvement.

ED FOSS, '32, supervised the technical details and kept accurate performance records of the two new power rigs of the Barnsdall Oil Company, Barnsdall's preference being for pumps driven by independent internal combustion engines with other compounded engines driving the drawworks and rotary machine.

BOB GARDNER, '36, and DON BLODGETT, '36, of the Richfield Oil Corporation, have been checking the hoisting characteristics of drilling rigs powered by both steam and internal combustion engines. Unfortunately, Don is now on sick leave with his folks at Balboa Island.

BOB RAMEY, '30, and WALTER MOORE, '23, of the Machinery Division, Republic Supply Company, have been active in sales of power drilling rigs. Both have been very helpful in assisting with new developments required for power drilling rigs in addition to their sales work.

LEROY NEWCOMB, '25, of Emsco Derrick & Equipment Company, has designed the new friction clutch drawworks developed largely for use with large power rigs. Leroy has also designed Emsco's hydraulic controls, oil-tite drawworks, hi-speed rotary machine, and is regarded as one of the best engineers in the Emsco organization. NICK D'ARCY, '29, is in charge of the Sales Office at Emsco and works closely with the Engineering Department on new products, relaying to the Engineering Departments trends reported from the fieldmen.

JIM KEELEY, '31, of Hillman-Kelly, is now selling the portable mast developed by the Franks Manufacturing Company. This mast is used with power drilling rigs on shallow holes where no derrick is erected.

At National Supply Company, five Cal Tech men are connected with power drilling equipment. BOB CRAIG, '21, and B. R. SCHABAKUM, '25, have been actively engaged in sales engineering work in the Mid-Continent, reporting many developments directly to National's Engineering Department. SPENCER LONG, '30, has been doing interesting stress analysis work in connection with rotary drilling equipment. M. W. HENSHAW, '36, is preparing sales data on power rigs in addition to development work on drawworks, and S. M. BROSE, '40, is connected with drawworks design.

(The writer wishes to thank at this time Barnsdall Oil Company, Richfield Oil Company, T. P. Pike Drilling Company, and Bell & Loffland for information and data contained in this article.)

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about not being able to change human nature, and about beautiful and impractical forms of society, and all this folderol about progress are due for some revision.

Rather wistfully, I sailed from Bali to Java, wended through its rice fields and tea plantations, circling around numerous volcanic peaks and climbing atop three of them. Then I sailed from Batavia to Singapore where I hoped to meet Bob Stirton, '30, then representing the Union Oil Company as a lubricating engineer, but he was in Bangkok. Fortunately, I met him on my return trip from India and he and his charming wife showed me the town. Later, under the flattering glow of cocktails, we recalled and eulogized other Caltech Alumni.

SECOND CLASS TO SINGAPORE

From Singapore, I sailed to Penang, Rangoon and finally Calcutta aboard a blacked-out British ship. A five-inch gun aft was constantly and itchingly attended, but no subs were sighted. The heat was terribly oppresive, but the company of a Chinese merchant, a poetic Hindu textile buyer, and a group of Indian soldiers including Sikhs, Hindus and Moslems was most informative and entertaining. Ordinarily, a white man wouldn't travel second class in India, which is one reason I was taken for a missionary, but in spite of certain difficulties it gives one a chance to "meet the people." None of the natives addressed me first, and they were reluctant when approached, but frequently became very talkative especially when they found I was an American. Stern Britishers looked on in horror from the adjoining first-class deck.

India formed the most amazing and impressive pageant I ever hope to see. I left the glittering golden pagodas of Burma where I had to walk barefoot amongst the Buddhist pilgrims and leprous begars to get my precious snapshots and see a weird misinterpretations of one of the world's greatest teachers. In Calcutta, I saw live sacrifices of goats to the awful goddess Kali in the old city of her name, Kalighat, which the English adopted as Calcutta. In the same city, I visited the Jain Temple, built with infinite care from millions of mozaics.

(Continued in Next Issue)

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