Engineering progress

ADVANCES MADE AT O. U.

WHAT IS GOING ON INSIDE OF THE CYLINDER?

BY W. H. CARSON

THE determination of pump characteristics when pumping mud-laden fluid is an important research project being conducted by faculty members and seniors in the school of mechanical engineering. On the conventional type of pump used in other industries for pumping oils, water, etc., much work has been done, but it is the responsibility of this group to do the pioneering work and make an analysis of the data on a slush pump. Since the space is limited only a portion of the findings will be included in this article, and this will be the part of the analysis made through the use of a highly refined instrument called an indicator.

Most of the readers of this article know that there are pressure and volume changes within the cylinder of a piston type reciprocating engine or pump. We, as engineers, are interested in knowing just when and how these changes take place, as this information is beneficial for future design and operation. The indicator spoken of is the engineer's eye through which a picture is drawn showing the exact relation between pressure and volume changes at the various points of the cycle. The instrument of this type used is indicated by the arrow shown in the photograph of the slush pump installed in our laboratories. The specially designed fluid chamber with separating diaphragm is immediately below the indicator. Typical cards drawn by an indicator are shown in the accompanying figure. The steam pump cards 1 and 2 show the events of the cycle as they take place; card 1 being from the fluid end of the pump, and card 2 from the steam end.

If one will bear in mind the fact that length on the card is proportional to the volume change as the piston of the engine or pump moves, and that height represents the corresponding pressure change, a brief analysis of the cards will be made. The horizontal lines AB and A′B′ represents atmospheric pressure; all distances above these lines will be gage pressures. Considering card 1 first, the events take place in the direction as indicated by the arrows, starting at point C the piston moves forward causing a pressure to build up in the cylinder due to the fact that fluid is being pumped. The wavy line from D to E indicates that the discharge valve opens then partly closes, re-opens, until the flow of fluid is sufficient to hold it entirely open. The pressure rises from E to F as the piston speed increases. From F to G the pressure falls slightly due to the fact that the piston speed is caused to decrease because of a back pressure building up on the opposite side of the steam piston, as shown from K′ to L′ on card 2. The rapid decrease in pressure from G to H would be expected if one studies card 2 and notes the rapidly increasing pressure from L′ to C′ which would tend to retard the piston movement until it comes to a stop at the end of the stroke. As the piston moves from this point to complete the cycle, fluid is drawn into the cylinder until the point C is reached.

Inspecting the steam or power card 2, steam is admitted from C′ to D′ and the piston is set in motion, moving as directed by the upper arrow. The wavy line D′E′ is a reflection of what is taking place in the fluid cylinder from D to E. The piston then moves to H′ where the opposing pressure of the fluid and compression pressure on the opposite end of the piston is sufficient to cause it to move back to I′. At this point the exhaust valve opens permitting the pressure to drop to J′. The steam pressure on the opposite side of the piston forces it on the return stroke to K′, which is the point of lowest pressure in the cycle. At this point the steam exhaust valve on the other cylinder opens causing the slight increase in pressure from K′ to L′. At L′ the exhaust port is closed and the pressure rises due to the intrapped cushion steam. Heretofore, authorities have considered the line J′K′L′C′ as the back pressure line when figuring mean effective pressure or the average pressure throughout the length of the stroke. This is not correct as the opposing presure will show on the indicator card taken from the opposite end. These two lines will not be coincident since the piston speed is not the same in both directions. This variation comes due to the fact that the ratio, steam piston area to pump piston area will not be the same because one will have the piston rod area deducted from it. With this finding the correct frictional resistance can be ascertained regardless of the direction of the stroke.

The indicator cards number 3 and 4 were taken from a steam turbine driven crank type pump. They are different in appearance to the power pump cards because of the angularity effect of the connecting rod and angular acceleration. Briefly explaining the events of the cycle of this type pump, reference will be made to card 4.

Starting at point M the pressure slowly rises until the suction valve closes, then there is a sudden rise to point N, causing a severe water hammer before the discharging valve opens. The wavy line between N and O is due to valve opening; a maximum pressure is reached and then falls to point P. Here only one side of the pump is pumping, the other having reached the end of its stroke. Immediately after P, the wavy line is a reflection of the discharge valve opening in the opposite cylinder. From this point to Q both sides are pumping. At Q the direction of motion of the piston is reversed and the pressure falls to R. The return stroke R to M is the suction stroke of the pump.

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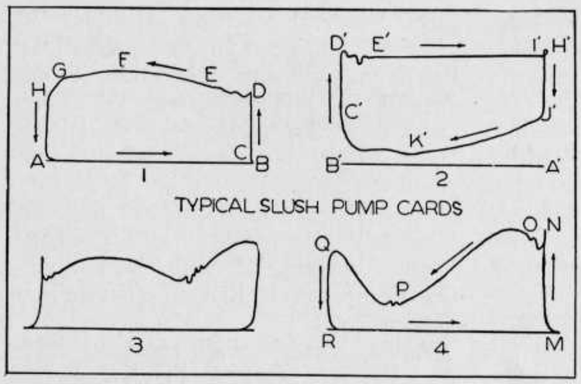


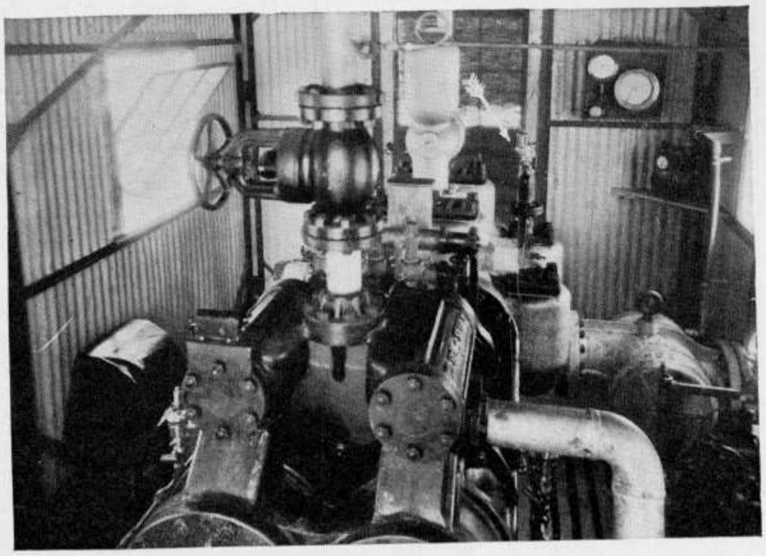
AN INSTRUMENT FOR THE STUDY OF HIGH SPEED

BY JOSEPH LISTON AND SYLVAN CROMER

WITH the increasing use of automobiles, trucks, and airplanes, and the ever more keen competition of manufacturers forcing reliability and performance to new and higher standards, it becomes necessary for engineers to KNOW what takes place inside the engine. This may not appear to be much of a problem, but a little study will show that it is very difficult.

Consider a modern automobile engine. Its speed range is from a few hundred revolutions per minute (RPM) to 3,500 or 4,000. Its

Laboratory slush pump with testing instruments in place



power developed varies from a few horsepower to 60, 80, 100 or more. It must use a low priced fuel, mix it properly with air, burn it completely and then get rid of it. It must start, stop, and perform under all kinds of exacting conditions and with far less care and attention than any other machine of comparable precision.

Suppose an engine is turning at 3,000RPM. In one minute 1,500 separate charges of a correctly proportioned mixture of fuel and air pass into each cylinder, are compressed, ignited, burned, expanded, and exhausted. Thus each charge has 1/1,500 of a minute or 1/25th of a second to pass through all these stages. And all the stages must occupy precisely their apportioned part of the time.

The compression stroke will occupy about one-half a revolution or 1/100th of a second. Ignition will occur at a certain predetermined number of degrees of crankshaft travel before the end of the compression stroke. The spark at the spark plug points must occur repeatedly at exactly the same point on the compression stroke. An idea of the precision to which the ignition system must function is had when we consider that a variation of 5 degrees of crankshaft travel in the time of reocurrence of the spark is more than would ordinarily be allowed, yet it represents a variation in time of only 1/3,600th of a second! Burning of the air and gasoline vapor occurs in not more than 90 degrees of crankshaft travel or 1/200th of a second and during this time the pressure rise may be 200 to 300 pounds. Expansion, exhaust, and intake each require approximately the same time as compression.

It is evident that the study of such phenomena as pressure variation in the engine cylinder during compression, burning, and expansion becomes very difficult due to the extreme rapidity with which the changes occur, yet facts on pressure changes, and many other phenomena occurring in the engine cylinder, must be known to the engineer if his company is to survive the exacting requirements of a public that neither understands nor cares about the difficulty of the problem.

For the older forms of engines, such as steam engines, slow speed gas, and Diesel engines, devices known as indicators are used to study pressure changes and to determine horsepowers. These indicators consist of small spring-loaded pistons in cylinders connected to the engine cylinder and having pointers which draw graphical representations of the pressure variations.

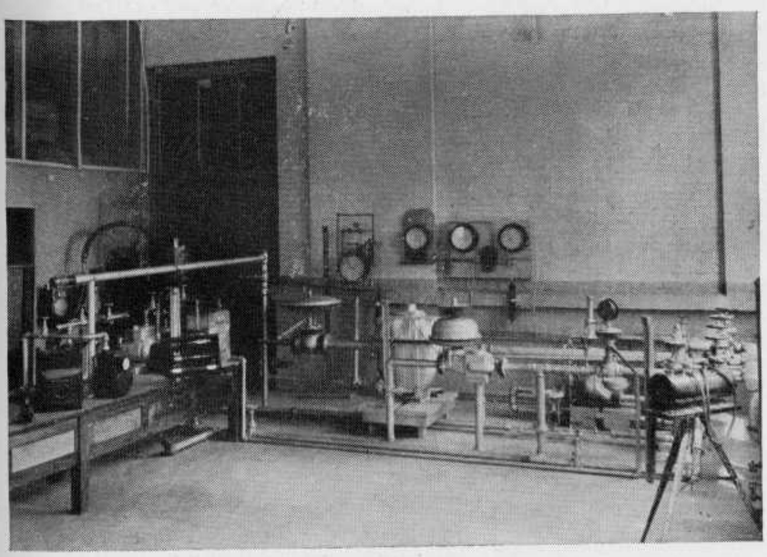
But such indicators are worthless on high speed automotive engines due principally to their inertia, i.e., their inability to "keep up" with the rapid pressure changes in the cylinder. It thus becomes necessary to resort to the use of so-called "High Speed Indicators."

There are many kinds of high speed indicators, but none has yet been developed that is entirely successful. The simpler ones are inaccurate and the more complicated ones are so difficult to keep in adjustment that an expert is required to handle them. Among the various types that have been developed might be listed the Micro Indicator, the Carbon Pile Indicator, the Sampling Valve Indicator, the Optical Indicator, and the Balanced Diaphragm Indicator. This last is a development of the U. S. Bureau of Standards. In a refined state it is a precision instrument.

The Balanced Diaphragm Indicator in the mechanical engineering laboratory, Fig. 1, operates on the same principle as the Bureau of Standards instrument. Precision machines were not available for its building and no great accuracy is claimed for it, but when in proper adjustment, it gives results at engine speeds three times the speed at which slow speed indicators will function. This type of indicator can be used up to speeds of 3,000RPM.

Briefly the description of the indicator is as follows: (See Fig. 2.)

The pressure variations in the combustion chamber of the engine cylinder A are transmitted through the spark plug B between the porcelain and the shell to the hole leading into the steel block C. The balanced diaphragm is located between blocks C and D. The diaphragm is a small disc of stainless steel about .002 of an inch in thickness. It is separated from block C by a thin copper gasket and from block D by a paper gasket suitable for



Portion of natural gas engineering laboratory

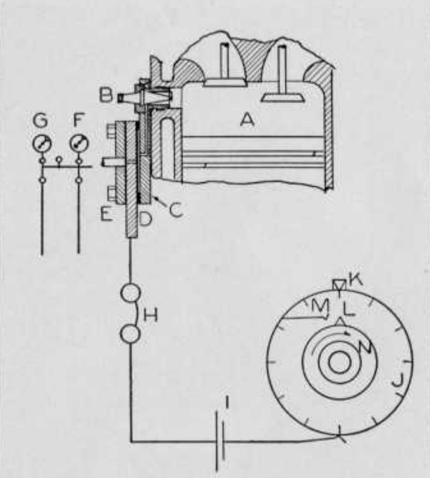


FIG 2 DIAGRAM SHOWING PRINCIPLE OF OPERATION OF THE BALANCED DIAPHRAGM INDICATOR

an electrial insulator. Block D is insulated from block E by a suitable paper gasket and thus provides one side of the electrical circuit.

Air pressure from a suitable source acts through the lines (shown schematically) on the opposite side of the diaphragm. The pressure is regulated by a needle valve and the amount of the pressure is read on gage G. During the time a new charge is being taken into the cylinder, the pressure in the cylinder is less than the atmospheric pressure. Thus, to study conditions at this part of the cycle, it is necessary to have a vacuum on the opposite side of the diaphragm. The amount of the vacuum is read on gage F.

The operation is as follows: Increasing pressure in the cylinder deflects the diaphragm until it touches block D thus completing the electrical circuit and causing a click in the head phones H. The deflections occur rapidly causing a series of clicks. Air pressure is now admitted to the opposite side of the diaphragm pushing it away from block D and stopping the clicks. At the pressure at which the clicks fade out or can no longer be heard, the air pressure is equal to the pressure in the engine cylinder and can be read on gage G.

The disc N which is grounded to the engine, rotates at one-half engine speed and electrical contact is made at points L and M. Disc J can be set by pointer K at any angle through 720 degrees or two revolutions of the engine shaft. This permits a study of any part of the cycle of operations since electrical contact must be had at the diaphragm and at points L and M at the same time in order to complete the electrical circuit and cause a click in the head phones. By taking pressure readings at increment angles through 720 degrees, data is had to construct an indicator card or for other studies.

This type of indicator has a negligible inertia lag and results represent an average of hundreds or even thousands of cycles, whereas low speed indicators are usually run for a few dozen cycles at the most and so cannot begin to represent average conditions as well.

The indicator is used in one of the experiments in internal combustion laboratory. Due to the difficulties which are inherent in all high speed indicator work, precise results are difficult to attain with students, but when the instrument is carefully adjusted, reliable data can be had.

To the knowledge of the writers, this is the only instrument of its kind in the middle west.

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THE EDUCATIONAL EXECUTIVE ORDER

(CONTINUED FROM PAGE 185)

to resume its study under the direction of Governor Murray.

It is not expected that the action of the governor and the economy committee will prevent the holding of the scheduled summer session of the university

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NOTE: Alumni of the university have offered their services to and are gladly working with the governor's committee, trusting that they may be of some assistance in eliminating duplication and effecting a more sound educational system for the state.

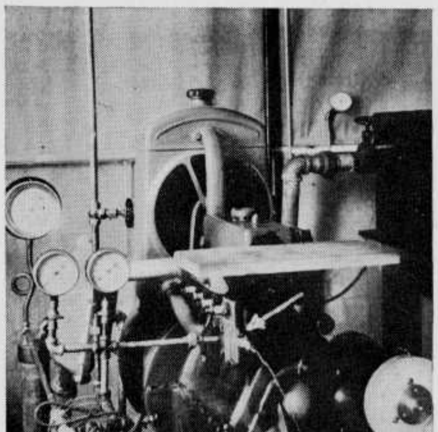

Figure 1—high speed indicator

ENGINEERING AT THE UNIVERSITY

(CONTINUED FROM PAGE 187)

science in this particular branch of engineering. The school usually has an enrolment of 35 students.

Scarcely less necessary than the specialist in particular branches of engineering is the specialist in physics who carries on research for the industrialist and the engineer. Since the World War research in industry has increased by leaps and bounds, and much of this research is of necessity highly theoretical. To make it possible to meet the demands for men with training for research, the school of engineering physics was organized in 1924 with an initial enrolment of five. In the brief space of time since its founding, the school has graduated four students, and now has an enrolment of ten. The story of the founding of this school again illustrates the process by which the college of engineering has been adapting itself to the new needs of the technical age.

In the same year that this school was founded, the school of petroleum engineering came into existence. The eight years of its existence have witnessed a growth in importance that has been little short of phenomenal. In its first year, the school had four students who planned to make its courses their major work; in 1933, there are 162 enrolled. One hundred and forty students have been graduated in petroleum engineering since 1924. The attention this school has drawn throughout the nation is one significant test of its value in an intensely specialized engineering world.

Finally, architectural engineering came into its own in 1927, after architectural courses had been offered at the university for a period of seven years. The name of the school was changed this year to the "school of architecture," and 60 students are enrolled.

Like so much of the history of Oklahoma, the history of the college of engineering is a chronicle of rapid progress. From small beginnings, it has grown to great stature, meeting as it has grown, the manifold problems of a pioneering state that has had to carve out for itself a place in industrial America. It has played no small part in the building of Oklahoma.

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Soonerland in brief

Sigma Chi fraternity has initiated into its Norman chapter Major H. J. Malony, commandant of the R. O. T. C. at the university.

The state house of representatives killed a bill proposed by Tom Z. Wright, '29bus, of Beaver, requiring entrance examinations in state schools.