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VALVE GEAR PROBLEMS

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THEORY

The function of the valve gear in an internal combustion engine is to admit the combustible charge into the combustion chamber before compression and to permit the expelling of the burned gases after expansion has taken place. Poppet valves are invariably employed and are associated with other parts such as springs, tappets, cams, and in some cases, pushrods and rocker arms. These parts employed as a mechanism comprise the valve gear of an engine.

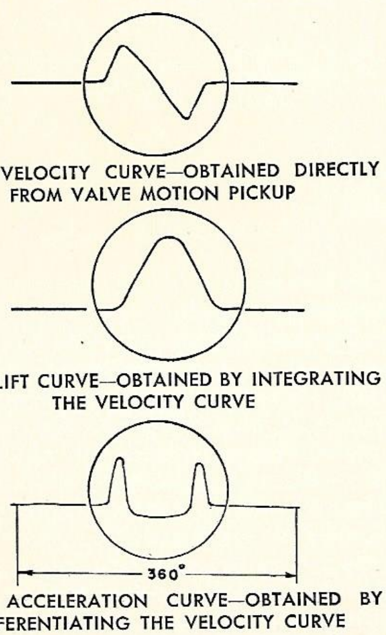


FIGURE 1
Theoretical valve motion curves

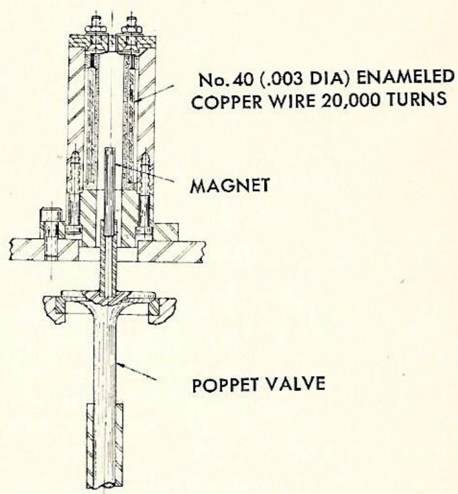
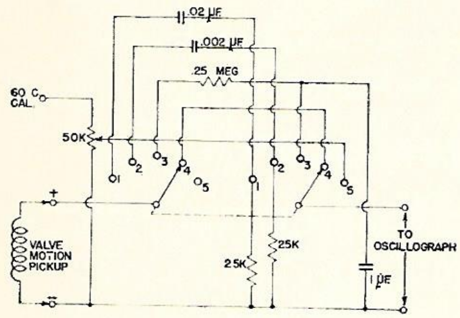


FIGURE 2
Valve motion pickup

To impart the required motion to the valves the cam is used. Its design is governed by engine power and torque requirements, by valve life, and other factors. Due to the flexibility of the various components and to a possible surge in the valve spring, the resulting valve motion departs measurably from the theoretical motion which the cam is designed to produce. Excessive departure from the theoretical adversely reflects on engine performance. When engines do not operate satisfactorily at high speeds, or have a short life for the valve gear components, this can be a major problem.

It becomes desirable to observe the motion of the poppet valve of an engine when operating at high speed. By observing the response of the valve gear it is possible to determine if the engine will measure up to the desired performance, and in other cases it is



1. LOW SPEED—VALVE ACCELERATION
2. HIGH SPEED—VALVE ACCELERATION
3. VALVE LIFT
4. VALVE VELOCITY
5. CALIBRATION

FIGURE 3

Circuit diagram for valve motion study

possible to find where a fault exists. The use of an oscillograph permits making these observations at high speed. The effect of changes in the valve gear, such as a cam contour, can be readily made.

The cam is designed to impart a definite lift motion or lift curve to the valve. This lift curve is based on valve velocity and valve acceleration curves. Typical curves are shown in Figure 1.

DESCRIPTION OF EQUIPMENT

The equipment used for this study of valve gear motion consists of a magnetic pickup, an electrical network, a cathode-ray oscillograph, and a synchronization trip. The type of magnetic valve motion pickup employed is illustrated in Figure 2. It comprises a permanent magnet which moves within a coil of wire rigidly mounted to the engine frame. As the magnet, which is attached to the poppet valve, reciprocates within this wire coil it generates a voltage which is equal to:

$$e_0 = k_1 \cdot N \cdot \frac{d\phi}{dt}$$

where: N = coil turns

$\frac{d\phi}{dt}$ = rate of cutting flux lines

but: $\frac{d\phi}{dt} = k_2 \cdot V$

where: V = valve velocity

therefore: $e_0 = k_3 \cdot N \cdot V$

Since the output voltage from this type of pickup is proportional to the valve velocity, a valve velocity curve will appear on the oscillograph when the output terminals from the pickup are connected directly to it. This is indicated by the first curve in Figure 1. A very linear response can be secured

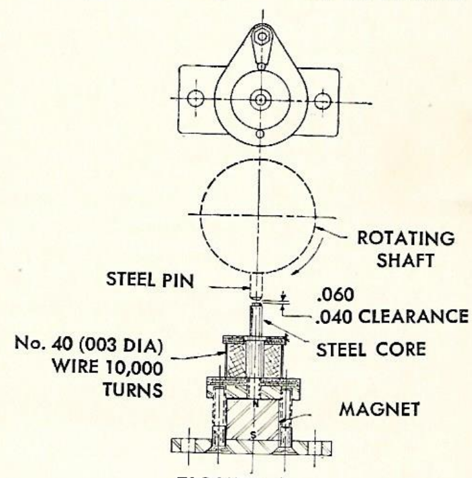


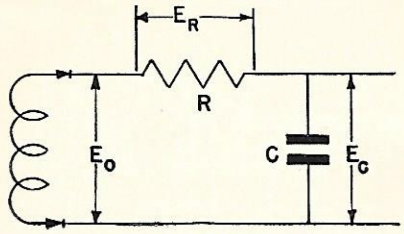
FIGURE 4

Synchronization trip

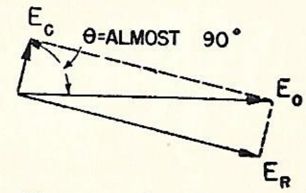
from this type of pickup when it is carefully designed.

To obtain either a valve lift curve or a valve acceleration curve an electrical network must be employed to integrate or differentiate the velocity curve. Basic circuits by which this may be accomplished are shown in Figure 5. Electrical integration is performed by utilizing a RC network with selected values to give a high ratio of resistance to capacitive reactance and a high ratio of time constant (RC) to the reciprocal of the frequency of operation (1/f). The integrated voltage

INTEGRATING NETWORK



Schematic Circuit
INSTANTANEOUS VOLTAGES



Vector Diagram for Sinusoidal Voltage from Pickup

$$e_o = e_r + e_c$$

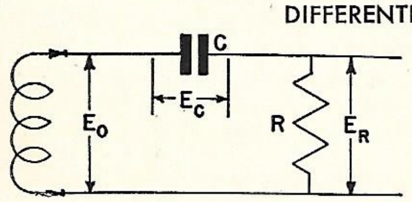
When $R \gg X_c$, $e_o \cong e_r$.

But $e_r = i \cdot R$ and $i = C\frac{de_c}{dt}$.

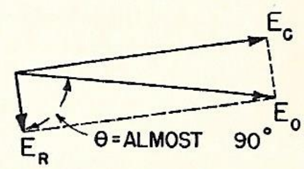
Therefore

$$e_c = \frac{1}{C}\int i \cdot dt = \frac{1}{C}\int \frac{e_r}{R}\, dt \cong \frac{1}{C \cdot R}\int e_o\, dt.$$

DIFFERENTIATING NETWORK



Schematic Circuit
INSTANTANEOUS VOLTAGES



Vector Diagram for Sinusoidal Voltage from Pickup

$$e_o = e_r + e_c$$

When $R \ll X_c$, $e_o \cong e_c$.

But $e_r = i \cdot R$ and $i = C\frac{de_c}{dt}$.

Therefore

$$e_r = C \cdot R\frac{de_c}{dt} \cong C \cdot R\frac{de_o}{dt}$$

FIGURE 5
Basic Circuits

appears across the terminals of the condenser. For the case of a sinusoidal voltage output from the pickup a vector diagram is indicated.

Electrical differentiation is also performed with an RC network as shown in Figure 5. In this instance the values are chosen to give a high ratio of capacitive reactance to resistance and a low ratio of time constant (RC) to the reciprocal of the frequency of operation (1/f). The differentiated voltage appears across the resistance. A vector diagram is shown for a sinusoidal voltage output from the pickup.

These two electrical networks are incorporated in the circuit diagram shown in Figure 3. A 60 cycle calibrating voltage is also provided to facilitate adjusting the gain control to predetermined settings.

The synchronization trip is employed to synchronize the horizontal linear sweep circuit of the cathode-ray oscillograph to the rotative speed of the camshaft. This device is illustrated in Figure 4. It consists of a coil or wire wound on a steel core and mounted on a permanent magnet. The motion of

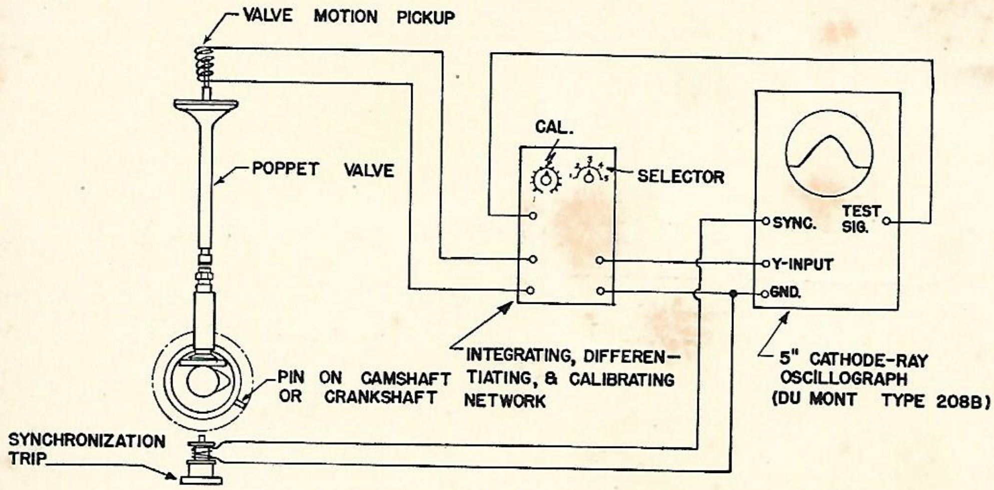


FIGURE 6
Arrangement of equipment for valve motion study

a steel pin past the core disturbs the magnetic flux passing thru the coil for a short interval to generate a voltage pulse to give synchronization.

ARRANGEMENT OF EQUIPMENT

A schematic diagram of the arrangement of equipment is shown in Figure 6. The simplicity is apparent as no added amplifier or voltage supply is needed. Though the diagram shows

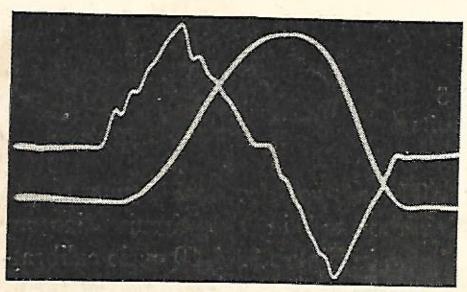


FIGURE 7
Lift and velocity curves at low speed

the pickup installed to the valve of an L-head engine, it may equally well be attached to the valve of a valve-in-head engine. When the pickup is mounted on the head end of the valve, observations are made by motoring the engine with a dynamometer. By attaching the magnet to the valve tip, of an engine employing rocker arms, valve motion curves can be obtained with the engine firing.

OBSERVATION AND RECORDING

After considerable experimentation with various methods of valve gear study, the cathode-ray oscillograph was selected to make the visual observations of the valve motion curves as it is the most convenient and economical instrument for this use.

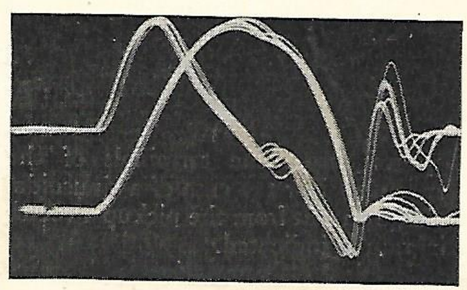


FIGURE 8
Lift and velocity curves at high speed

Typical valve lift and velocity curves obtained in this manner are shown in Figures 7 and 8. Unsatisfactory valve gear performance is revealed by Figure 8 and suggests that changes be made in the cam design and in the valve spring.