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Author	堀内, 敏夫(Horiuchi, Toshio) 小茂鳥, 和生(Komotori, Kazunari) 鬼頭, 史城(Kito, Fumiki) 三好, 栄(Miyoshi, Sakae)
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Measuring Device for Instantaneous Fuel Flow in Simple Carburetters

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Toshio HORIUCHI*
Kazunari KOMOTORI**
Fumiki KITO***
Sakae MIYOSHI****

Abstract

An elastic reed flow meter using a foil strain gauge, which is responsible to the pulsation of up to 40 cps and has the sensitivity of 0.001 cc/stroke was developed. The application of the detector to the measurememt of instantaneous fuel flow through simple carburetter nozzle is described.

I. Introduction

The flow rate meters which have been hitherto used for the measurement of fuel consumptions are not applicable for that of instantaneous flow rate through carburetter nozzle, since the output of the former corresponds to the mean flow rate depending on their frequency response and on the system to be measured. Therefore in order to analyse the dynamic characteristics of gasoline engines, for example, instantaneous values of input signals must be essentially obtained. Among such signals, the rate of fuel flow through nozzle system was the most difficult one to measure, as the construction of carburetters is usually so complicated that the way of the measurement is seriously restricted from their sizes and structures, that is, flow meters already developed were scarcely suitable to be built in the system to be measured. To know such a flow rate which intermits in each stroke, the response of the detector and its sensitivity play an important and fundamental role, besides we have little information about the values of such signals. Then the results obtained here might be a kind of first order approximations to give some rough informations as to carburetter characteristics in engine systems. But it is supposed that the device will be modified further by mechanical and control engineers to be used for their special purposes.

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*堀内敏夫 Professor, Faculty of Engineering, Keio University.
**小茂鳥和生 Professor, Faculty of Engineering, Keio University.
***鬼頭史城 Professor, Faculty of Engineering, Keio University.
****三好栄 Nagoya-Kiki Works, Mitsubishi Heavy Industry Co.,

II. Flow rate transducer

The device which has been reported before[1] was made of thin phosphor bronze orifice plate which was inserted in the fuel supply tube directly before the nozzle and the deflection of which was detected as capacity change in connection with another stationary electrode. The change of the capacity was measured by any conventional frequency sensing device with high accuracy But since such a detector may be easily affected by vibratory movements of engines, a special test stand must be designed to eliminate the disturbances. To avoid the difficulty mentioned above, a foil strain gauge is used here.

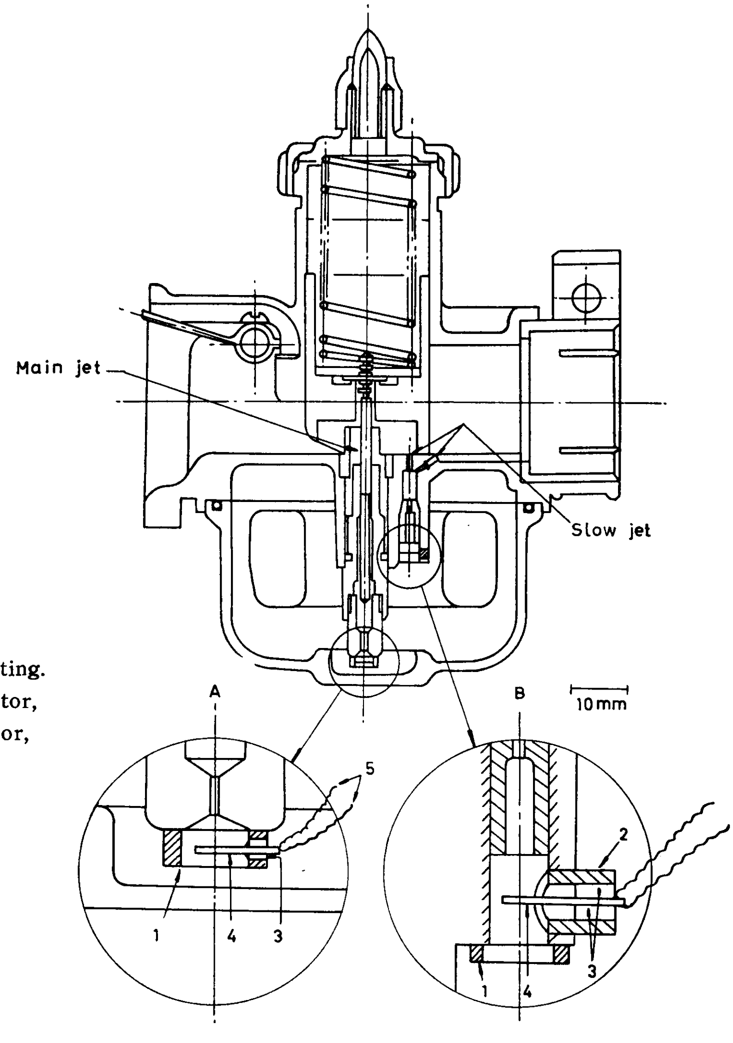

Fig. 1.
Flow detector mounting.
A; main jet detector,
B; slow jet detector,
1; bakelite ring,
2; brass ring,
3; insulating plug,
4; strain reed,
5; lead wire.

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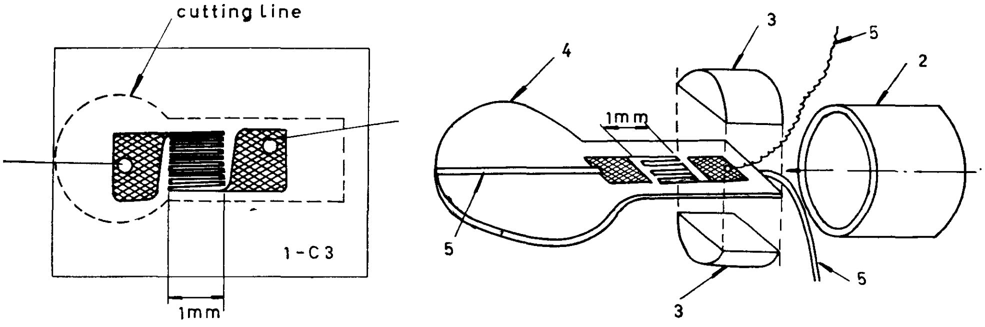
1) Hatta, Nakahara, Ishida and Nishihara; Read at the meeting of Jap. Soc. Mech. Eng. 1963,

To keep the frequency response of a detector enough high, its inertia must be as possible as small. At the same time the loading or the energy loss due to the detector elements must be reduced, since the device may disturb the usual and sensitive carburetter action. Thus a foil strain gauge of 1 mm gauge length was chosen. The arrangement of the detector is shown in Fig. 1. The reed is cut out from the strain gauge with bakelite base of thickness 4/100 mm in a suitable size as shown in Fig. 2. Along the base foil, a galvanometer strip wire which serves one of lead wires is adhered in its back side. The sensitivity of the detector can be adjusted by adhering phosphor bronze foil of suitable thickness instead of the strip wire. The natural frequency of the reed was about 400 cps and no special damping device was necessary when it is immersed in the fuel. Then the reed is responsible to the measurement up to about 2400 rpm for single cylinder 2 cycle engine which is used in this work*. Now, one tenth of the natural frequency is supposed to be the frequency response of the reed. The detector is easily mounted in the main and slow nozzles without any serious change in the system and the flow signal through each of them could be recorded separately. The example of the calibration curve is shown in Fig. 3. Here the output is not proportional to the flow rate as will be expected from the differencial principle. Therefore, for the measurement of the rate per



(*a*) (*b*)

Fig. 2. Strain reed composition. (*a*) Cutting of foil strain gauge; (*b*) Assembly, the numbers correspond to that in Fig. 1.

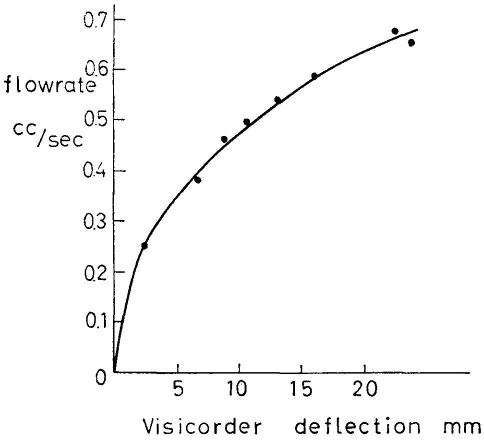


Fig. 3. Calibration curve of strain reed flow meter.

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*Mitsubishi NE 43B 125 cc engine.

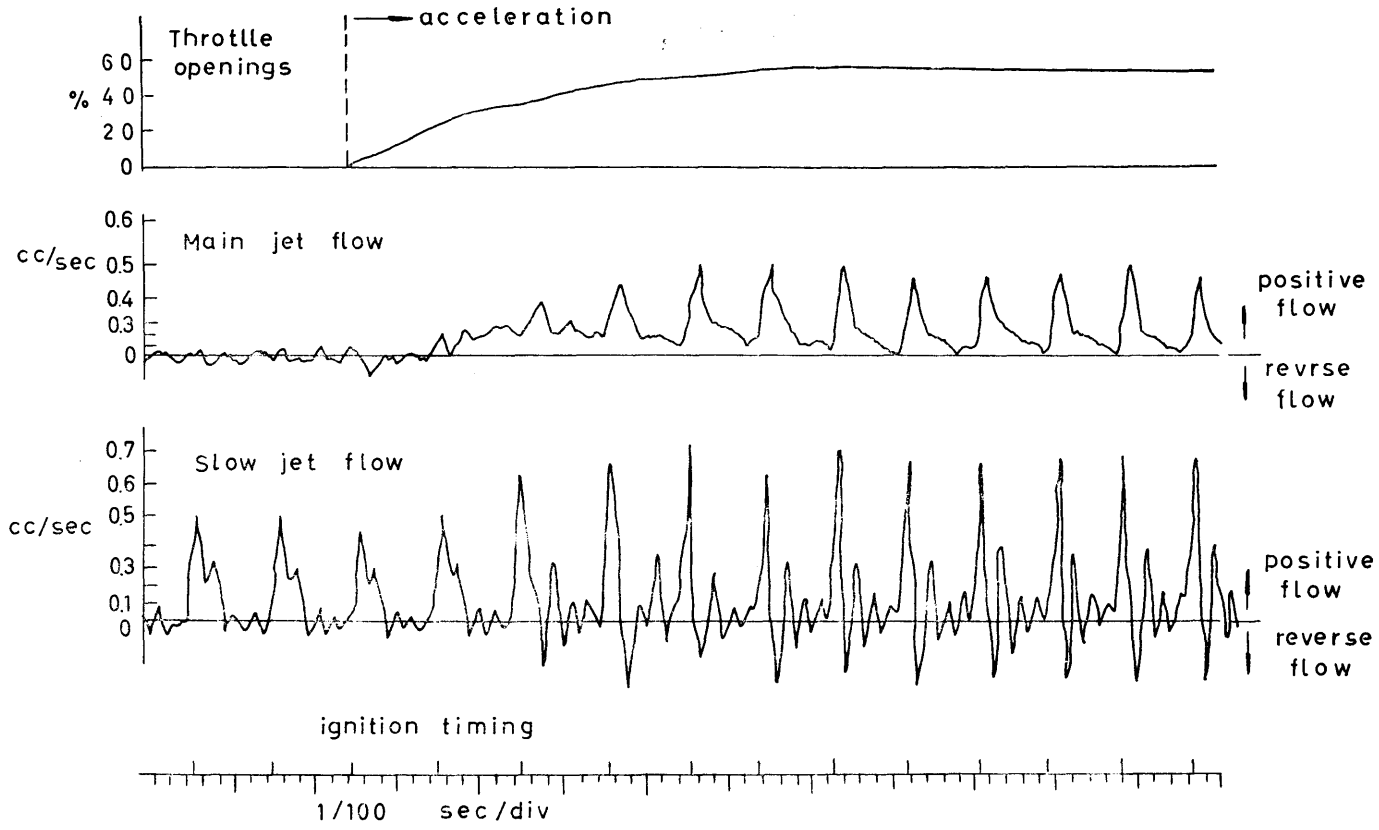

Fig. 4. Visigraphs of throttle opening, main jet flow, slow jet flow and firing mark.
The downwords throw in the slow jet signals reveals the reverse flow, whih diminishes the interval of positive flow, resulting the decrease in the integrated fuel flow per stroke.

one stroke, non-linear integration of the instantaneous values must be carried out. The output of the strain meter was recorded by Honeywell 906 C Visicorder oscillograph using Heiland M 100—120 galvanometer. The sensitivity of the flow meter is about 0.001 cc per one suction stroke.

III. Results

An example of observed rates of flow in main and slow nozzles during an accerelating stage of the engine with the record of throttle openings and the ignition timing together are shown in Fig. 4. As the natural frequency of the reed is 400 cps, the vibrating signals of about 70 cps which is observed in slow nozzle flow seems to be independent with the natural frequency of the reed.

As the values obtained from such oscillograph in steady state operation shows close agreement with that of fuel consumption data obtained by an usual method, the function of the device seems to fulfil the needs considered above. Some features of engine accerelation in connection with the measurement will be mentioned below.

In Fig. 5 is shown the plot of flow rate change with time as an example. In the special case where throttle is opened suddenly, marked decrease of flow rate is observed as shown in the figure. Since the event corresponds to the marked

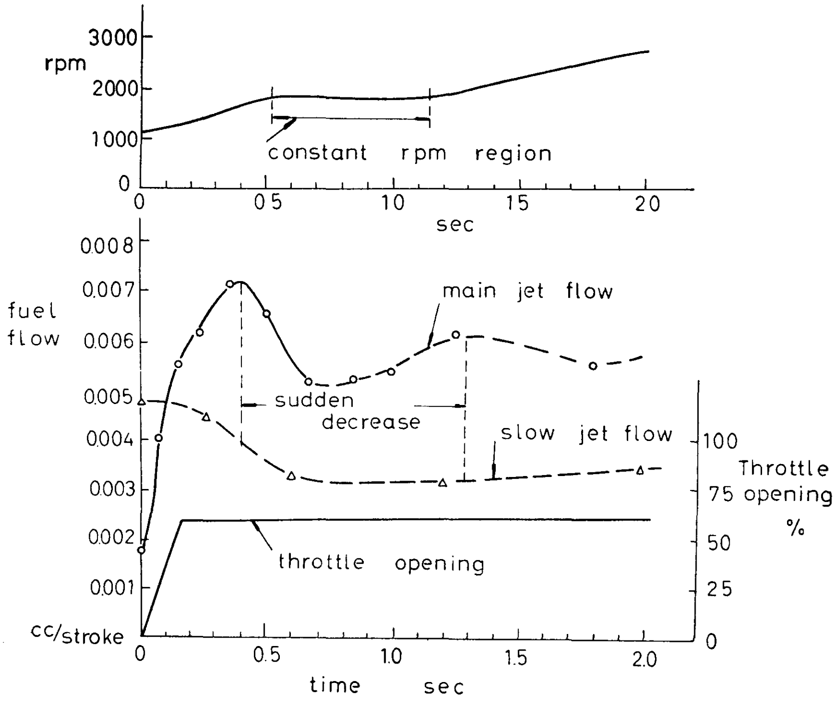

Fig. 5. Accerelation characteristics of fuel flow.

decrease in the output torque, it may be interesting to explain where the cause lies. Briefly speaking, in Fig. 4, it was remarkable for reverse flow to take place in this case, but the reverse flow disappears if the engine gets some higher rpm. Thus it may be concluded that the optimal throttle opening must exist as a function of rpm. In fact, gradual opening of the throttle did not cause such reverse flow and torque decrease. The relation between degree of opening and rpm in connection with the happening of the reverse flow is shown in Fig. 6.

Similar results were reported by N. H. Diyachenko and P. M. Below[2]. Therefore it will be suggested that the analysis of engine performance will become decisive by the measurement of input and output signals in the system.

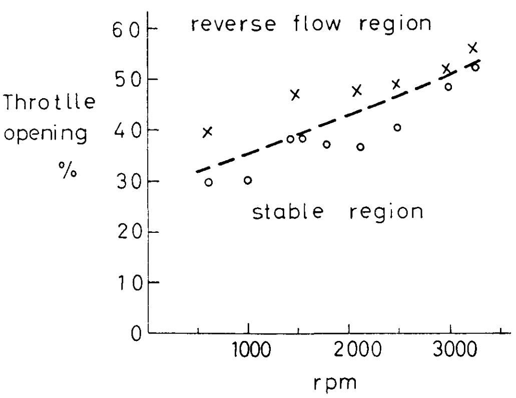

Fig. 6. Stable fuel flow can be obtained as a function of throttle opening.

IV. Conclusions

A reed type strain flow meter was developed which satisfactorily measures the instantaneous flow rate in a simple carburetter. The flow signal obtained by this device can reveal the transient characteristics of an engine system, by which further developments of engine design and of trouble shooting are to be expected. The construction of the detector is simple and the size is reasonably small that the measurement of flow signal in more complicated carburetters becomes probable.

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[2] N. H. Diyachenko and P. M. Below, Automobilinaya Promishlenaschi, 1959.