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⑤④ **THROTTLE-POSITION SENSOR FOR AN ELECTRONIC FUEL-INJECTION SYSTEM.**

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FR-A-2 406 727
GB-A-2 103 837
GB-A-2 156 543
US-A-3 888 458</p> <p>Patent Abstracts of Japan, volume 9, no. 316
(M-438)(2039), 12 December 1985, & JP, A,
60151445 (Nissan Hidosha K.K.) 9 August 1985</p> | <p>⑦③ Proprietor: BRUNSWICK CORPORATION
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Description

This invention relates to electronic fuel-injection circuitry for internal-combustion engines and is more particularly concerned with generation of suitable throttle-responsive fuel-flow control signals used in such circuitry.

Reference is made to our U.S. Patents Nos. 4,305,351 and No. 4,349,000 for detailed discussion of pulse-width modulating circuitry for operation of the solenoids of fuel-injectors in a variety of engines of the character indicated. The disclosure in these patents, for example in connection with Fig. 6 of U.S. patent 4,349,000 is concerned with circuit accommodation of various input parameters, in the form of analog voltages which reflect air-mass flow for the current engine speed, and a correction is made for volumetric efficiency of the particular engine, to arrive at a pulse-width modulating voltage E_{MOD} in a line to each of two like square-wave pulse generators. These pulse generators respectively serve for fuel-injection control in different groups of cylinders in the involved engine. The input parameters include engine speed and throttle setting, and the disclosure is for a potentiometer to track throttle setting, which is the customary provision for general public acceptability—i.e., for normal commercially satisfactory performance.

US—A—3,888,458 also discloses similar pulse-width modulating circuitry in which actual engine air flow is measured by means of a mass flow air meter to provide a signal output to such circuitry for combination with signals representing other engine operating parameters. Thus, signals representing rpm and the pressure drop across the throttle valve in the intake are also developed in this reference. Engine load, however, is determined in the aforesaid customary manner by a transducer connected by a mechanical link to the throttle.

GB—A—2 103 837 discloses an electronic fuel injection system employing circuitry responsive to a number of engine operating parameters including intake air pressure and temperature as well as engine speed. This latter parameter, however, is determined again by the customary means noted above, namely, that a so-called fuel command potentiometer provides a control voltage representative of engine speed is mechanically coupled to the accelerator pedal by a linkage.

It is therefore desired to provide improved means for effectively translating throttle position into a suitably related fuel-flow control signal, for engines of the character indicated.

The present invention is therefore directed to improvements in an electronic fuel-injection control circuit for an internal-combustion engine, wherein throttle setting and tachometer output are necessary ingredients in the generation of an electrical control signal for pulse-width modulation of a square-wave generator of fuel-injector excitation pulses, characterized in that the electrical control signal is derived from only a first signal and a second signal, said first signal being derived from only engine speed as reflected by said tachometer output, said second signal being derived from engine speed as reflected by said tachometer output and from a differential-pressure transducer which is connected to track the instantaneous pressure drop across an operator controlled throttle as well as the instantaneous manifold vacuum condition of the engine, said second signal not including a component of a signal derived from a directly measured throttle position.

The invention has a number of advantages including the ability to produce an output signal reflecting throttle position without use of a potentiometer or any other mechanical means to track throttle position.

Additionally, the invention accomplishes this result with means affording inherently greater life, and superior performance and reliability, in racing use of such engines. Since the invention has no mechanical tie to the throttle, there is none of the hysteresis or mechanical wear that are characteristic of conventional throttle-position sensors.

In a preferred embodiment the invention comprises a tachometer circuit which is modulated by the signal from a differential-pressure transducer, connected to track the instantaneous hydraulic pressure drop across the engine throttle. The tachometer output controls the duty cycle of a pulse generator which, in turn, drives an output transistor; a reference potential is applied across the load resistor and emitter of this output transistor, and the output signal is obtained as a d-c control signal, upon filtering the signal from the collector of the output transducer.

The transfer function of the device yields maximum output when there is little or no intake vacuum, e.g., at sustained high speed, and minimum output is obtained from minimum speed and maximum vacuum.

A preferred embodiment of the invention will be described in detail in conjunction with the accompanying drawings, in which:

Fig. 1 is an electrical block diagram, schematically indicating components of circuitry of the invention, in the context of other components of fuel-injection control circuitry, applicable to a variety of different fuel-injection engines; and

Fig. 2 is a more explicit circuit diagram to show detail of the presently preferred component combination of the invention.

The diagram of Fig. 1 is similar to Fig. 6 of U.S. Patent No. 4,349,000, in order to show context for Fig. 2 circuitry of the invention, the same being shown in Fig. 1 as signal-processing circuitry 10, operative upon tachometer voltage E_T and being modulated by the output signal of a differential-pressure transducer 11 connected for response to the instantaneous drop in pressure across the engine throttle 12. This pressure drop will be understood to be a function of the negative-pressure or vacuum condition at the intake

manifold of the engine; specifically, at full throttle and maximum speed, the pressure drop to zero or near zero, and the pressure drop is greatest at minimum throttle (and therefore at minimum engine speed). The modulated-signal output of the signal-processing circuitry 10 is supplied as a d-c analog voltage for multiplication at 13 with a voltage E_M , and the product of this multiplication is a fuel-control voltage E_{MF} : in other words, the elements 10, 11, 12 and 13 of Fig. 1 replace the potentiometer 53 and throttle control 54 of Fig. 6 of U.S. Patent No. 4,349,000. The expression "Throttle-position" at multiplier 13 in Fig. 1 will be understood to express the effective accomplishment of mechanically tracking throttle position, without having resort to any mechanical motion-tracking to achieve this result.

As suggested by legends in Fig. 1, the circuit of Fig. 1 is shown in application to the development of fuel-injection voltage pulses for operation of a two-cycle V-6 engine described in detail in U.S. Patent No. 4,349,000, and said circuit operates on various input parameters, in the form of analog voltages which reflect air-mass flow for the current engine speed, a correction being made for volumetric efficiency of the particular engine, to arrive at a modulating-voltage output E_{MOD} in a line 15 to each of two like square-wave pulses generators 16—17. Depending upon the magnitude of the modulating voltage E_{MOD} in line 15, the square-wave output at 18 will be of predetermined duration, and the square-wave output at 19 will be of duration identical to that in line 18, it being understood that the predetermined duration is always a function of instantaneous engine-operating conditions.

More specifically, for the circuit shown, a first electrical sensor 20 of manifold absolute pressure is a source of first voltage E_{MAP} which is linearly related to such pressure, and a second electrical sensor 21 of manifold absolute temperature may be a thermistor which provides a voltage linearly related to such temperature, through a resistor network 22. The voltage E_{MAP} is divided by the network 22 to produce an output voltage E_M , which is a linear function of instantaneous air-mass or density at inlet of air to the engine. A first amplifier A_1 provides the output voltage E_M which is one of the inputs to multiplier 13. The voltage product E_{MF} of multiplier 13 reflects instantaneous air-mass flow for the instantaneous effective throttle (12) setting and engine speed, and a second amplifier A_2 provides a corresponding output voltage E_{MF} for application to one of the voltage-multiplier inputs of a modulator 25, which is the source of E_{MOD} . The other voltage-multiplier input of modulator 25 receives an input voltage E_E which is a function of engine speed (tachometer 26) and volumetric efficiency (network 27).

Referring now to Fig. 2 wherein "VDD" will be understood to mean connection to the engine's regulated power supply (not shown in detail), about 8 volts; and legend indicates use of the engine alternator (not shown) to provide a tachometer function by reason of its frequency dependence upon engine rpm. This alternator voltage enters the signal-processing circuitry at a filter R_1 — C_1 , so that the alternator output frequency in the voltage across an amplifier-input resistor R_2 can be clean, i.e., free of high-frequency (rf) noise. High-gain amplification via a transistor Q_1 converts the sinusoidal output of the alternator to a square-wave voltage (at alternator frequency) across a resistor R_3 . A capacitor C_2 differentiates the square-wave voltage, producing a series of sharply defined positive pulses; after diode clipping at D_2 , only the negative voltage pulses remain across a resistor R_4 , for recycle-triggering of an integrated circuit IC_1 , which may be of the type-555 variety, connected for operation as a monostable multivibrator. Circuit constants are suitably selected so that such triggering results from cut-off of each rising multivibrator voltage at about the 2/3 VDD point.

A differential-pressure transducer 30 may include a strain-gage bridge 31, for developing an electrical response to the instantaneous pressure drop across the throttle 12 of Fig. 1. As shown, this electrical response is processed by operational amplifiers 32—33 and associated resistors R_{16} , R_{17} (as trimmed at R_{27}) and R_{18} , to deliver a multivibrator-modulating voltage in the range from zero or near-zero, to six volts; this modulating voltage appears at the connection 34 between resistors R_7 — R_8 and is determinative of the level at which each recycled multivibrator-voltage rise commences. The multivibrator output appears across a resistor R_5 as a succession of square-wave voltage pulses at tachometer frequency and with a duty cycle which is an inverse function of the voltage derived from the pressure drop across throttle 12. Filter action via elements R_6 — C_4 smooths this pulsing voltage to a d-c voltage at the positive (+) input of an operational amplifier 35, connected as a buffer, for isolation of its d-c voltage output across a resistor R_9 .

It can be observed that the described utilization of IC_1 and its associated circuitry is to produce an electrical-signal output which is the quotient of instantaneous engine speed divided by instantaneous pressure drop across the throttle. And both the numerator and denominator voltage values relied upon for the quotient are individually proportioned to the same power-supply voltage VDD, thus inherently cancelling any quotient dependence upon fluctuations in power-supply voltage.

The smoothed and buffered quotient voltage which appears across resistor R_9 contains all the effective "throttle-positioning" data needed for replacement of the mechanically tracking throttle potentiometer 11 of Fig. 1 of U.S. patent No. 4,349,000, the only remaining problem being that of effectively multiplying the voltage E_M by this quotient voltage to achieve the voltage E_{MF} needed by the control unit 25.

In the form shown, the effective multiplication is achieved by connecting the voltage E_M across a switching transistor Q_2 and its load resistor R_{14} , and by using the quotient voltage value to control the duty cycle of switch Q_2 ; the resulting time-modulated output is smoothed by filter means R_{13} — C_6 to yield the d-c output voltage E_{MF} , needed by the control unit.

More specifically, a second integrated circuit IC_2 , which may also be the same type 555 as IC_1 , is connected with associated circuitry as a sawtooth generator 35, operating at a frequency of about 1000 Hz

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and supplying its sawtooth-voltage output to the positive (+) input of an operational amplifier 36. The latter is connected as a comparator, with quotient voltage applied to the negative (-) input. The sawtooth voltage thus recurrently scans the current level of quotient voltage to determine the on/off duty cycle of the switching transistor Q_2 .

5 Further specifically, for stabilized presentation of current quotient values within a desired 2 to 5-volt range and level at the negative (-) input of comparator 36, the quotient voltage at R_9 is applied via a coupling resistor R_{10} to the connection point 37 of resistors R_{11} — R_{12} which divide the power-supply voltage VDD.

10 The described circuit will be seen to achieve all stated objectives. In particular, throttle position is effectively sensed at all times, without resort to any mechanical tracking of throttle position. The result is hysteresis-free operation which is insensitive to vibration and which portends greatly extended life, under the most demanding conditions of racing performance.

Specific component values for elements indicated in Fig. 2 may be listed as follows:

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A. Resistors:

$R_1=10K$ ohms	$R_{14}=2K$ ohms
$R_2=10K$ ohms	$R_{15}=100K$ ohms
$R_3=6.8K$ ohms	$R_{16}=100K$ ohms
$R_4=20K$ ohms	$R_{17}=619$ ohms
20 $R_5=6.8K$ ohms	$R_{18}=866$ ohms
$R_6=100K$ ohms	
$R_7=332K$ ohms	$R_{19}=1K$ ohms
$R_8=634K$ ohms	$R_{20}=33K$ ohms
$R_9=1K$ ohms	$R_{21}=300K$ ohms
25 $R_{10}=71.5K$ ohms	$R_{22}=100K$ ohms
$R_{11}=100K$ ohms	$R_{23}=10K$ ohms
$R_{12}=150K$ ohms	$R_{24}=100K$ ohms
$R_{13}=10K$ ohms	$R_{27}=500$ ohms

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B. Capacitors:

$C_1=1$ μ f	$C_5=1$ μ f
$C_2=0.02$ μ f	$C_6=10$ μ f
$C_3=0.01$ μ f	$C_7=0.01$ μ f
35 $C_4=1$ μ f	$C_8=0.01$ μ f
	$C_{11}=0.005$ μ f

C. The four operational amplifiers (32, 33, 35, 56) are suggested by legend to be individual quarter segments of a single integrated circuit component IC_2 , variously connected as above described.

40 Claims

1. An electronic fuel-injection control circuit for an internal-combustion engine, wherein derived throttle setting and tachometer output are necessary ingredients in the generation of an electrical control signal for pulse-width modulation of a square-wave generator of fuel-injector excitation pulses, wherein
45 said electrical control signal (E_{mod}) is derived from only a first signal (EE) and a second signal (EM+), said first signal (EE) being derived from only engine speed as reflected by said tachometer output, said second signal (EM+) being derived from engine speed as reflected by said tachometer output and from a differential-pressure transducer (30) which is connected to track the instantaneous pressure drop across an operator controlled throttle as well as the instantaneous manifold vacuum condition of the engine, said
50 second signal (EM+) not including a component of a signal derived from a directly measured throttle position.

2. The device of claim 1, characterized in that the engine includes a local voltage supply, and in which each of said first and second signals (EE, EM+) is an independent function of the voltage output of said supply.

55 3. The device of claim 1 or 2, characterized in that the tachometer is an alternator whereby the frequency of said first signal (EE) is indicative of engine speed, said device including a square-wave generator (Q_1) connected for operation by said first signal (EE) to produce a square-wave output at alternator frequency, and in which the modulation by said second signal (EM+) is a duty-cycle modulation of said square-wave generator (Q_1), the sense of such modulation being inverse as between the direction of
60 second-signal change and the direction of resulting duty-cycle change.

Patentansprüche

1. Elektronische Steuervorrichtung für das Einspritzen von Kraftstoff in einem Verbrennungsmotor, in
65 dem eine abgeleitete Drosselklappen und ein Tachometerausgangssignal notwendige Größen für die

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Erzeugung eines elektrischen Steuersignals für die Impuls Impulsdauermodulation eines Rechteckwellengenerators für die zum Ansteuern einer Kraftstoffeinspritzdüse sind, dadurch gekennzeichnet, daß das elektrische Steuersignal (E_{mod}) nur von einem ersten Signal (EE) und einem zweiten Signal (EM+) abgeleitet wird, daß das erste Signal (EE) nur von der durch das Tachometerausgangssignal dargestellten angegebenen Motordrehzahl abgeleitet wird, daß das zweite Signal (EM+) von der durch das Tachometerausgangssignal angegebenen Motordrehzahl und von einem Druckdifferenzwandler (30) abgeleitet wird, der so geschaltet ist, angeschlossen ist, daß er den Momentandruckabfall an einer von einer Bedienungsperson gesteuerten Drosselklappe und das Momentanvakuum im Krümmer des Motors überwacht, wobei das zweite Signal (EM+) keine Komponente eines Signals enthält, das von einer direkt gemessenen Drosselklappenstellung abgeleitet ist.

2. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß der Motor eine Lokalspannungsquelle besitzt und daß das erste und das zweite Signal (EE, EM+) jeweils eine unabhängige Funktion der Ausgangsspannung dieser Quelle ist.

3. Vorrichtung nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß der Tachometer ein Wechselstromgenerator ist, so daß die Frequenz des ersten Signals (EE) die Motordrehzahl angibt, daß die Vorrichtung einen Rechteckwellengenerator (Q_1) besitzt, der auf Grund des ersten Signals (EE) einen Rechteckwellenausgang mit der Frequenz des Wechselstromgenerators erzeugt, und daß die Modulation durch das zweite Signal (EM+) eine Tastverhältnismodulation des Rechteckwellengenerators (Q_1) ist, wobei die Richtung dieser Modulation der Richtung der die Veränderung des zweiten Signals bewirkten Veränderung des Tastverhältnisses entgegengesetzt ist.

Revendications

1. Circuit électronique de commande d'injection de carburant, pour un moteur à combustion interne, selon lequel les signaux de sortie d'un tachymètre et d'un organe de réglage de papillon sont des données nécessaires pour la génération d'un signal électrique de commande, en vue de la modulation en largeur d'impulsion, d'un générateur d'onde carré produisant des impulsions d'excitation d'injecteur de carburant, dans lequel le signal électrique de commande (E_{mod}) est dérivé seulement d'un premier signal (EE) et d'un second signal (EM+), ledit premier signal (EE) étant dérivé uniquement de la vitesse du moteur telle que fournie par le signal de sortie du tachymètre, le second signal (EM+), étant dérivé de la vitesse du moteur, telle que fournie par le signal de sortie du tachymètre, et d'un transducteur de pression différentielle (30) qui est branché pour suivre la chute de pression instantanée au niveau d'un papillon contrôlé par un actionneur ainsi que la condition de vide instantané dans le collecteur du moteur, ledit second signal (EM+) ne comprenant aucune composante de signal dérivé d'une position directement mesurée du papillon.

2. Le dispositif de la revendication 1, caractérisé en ce que le moteur comprend une source d'alimentation en tension locale, et dans lequel chacun des premier et second signaux (EE, EM+) est une fonction indépendante de la tension de sortie de la source d'alimentation.

3. Le dispositif de la revendication 1 ou 2, caractérisé en ce que le tachymètre est un alternateur dans lequel la fréquence du premier signal (EE) est représentative de la vitesse du moteur, le dispositif comprenant un générateur d'onde carré (Q_1) branché pour être commandé par le premier signal (EE) et pour produire un signal de sortie carré à la fréquence de l'alternateur, et dans lequel, la modulation par le second signal (EM+) est une modulation de rapport cyclique, du générateur d'onde carré, le sens de cette modulation étant tel que le sens de changement du second signal et le sens de changement résultant du rapport cyclique soient inverses.

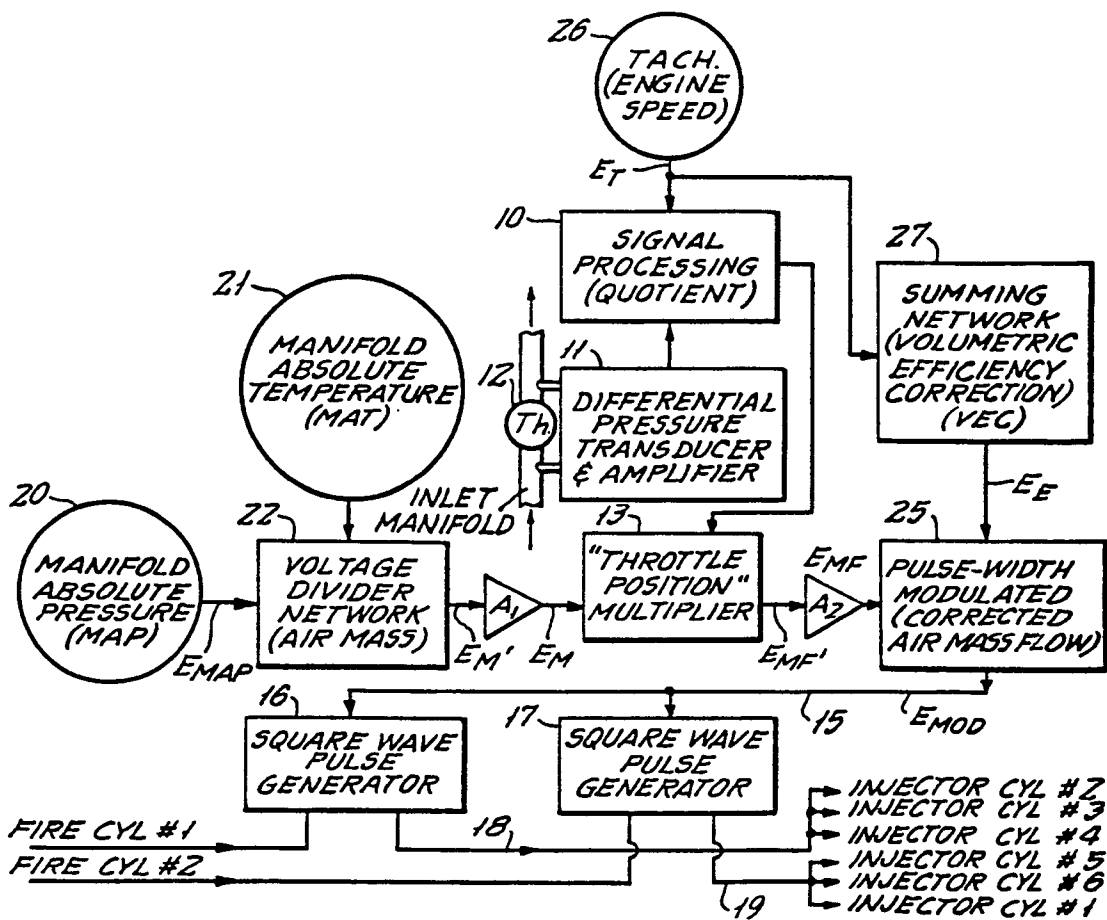
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FIG. 1.



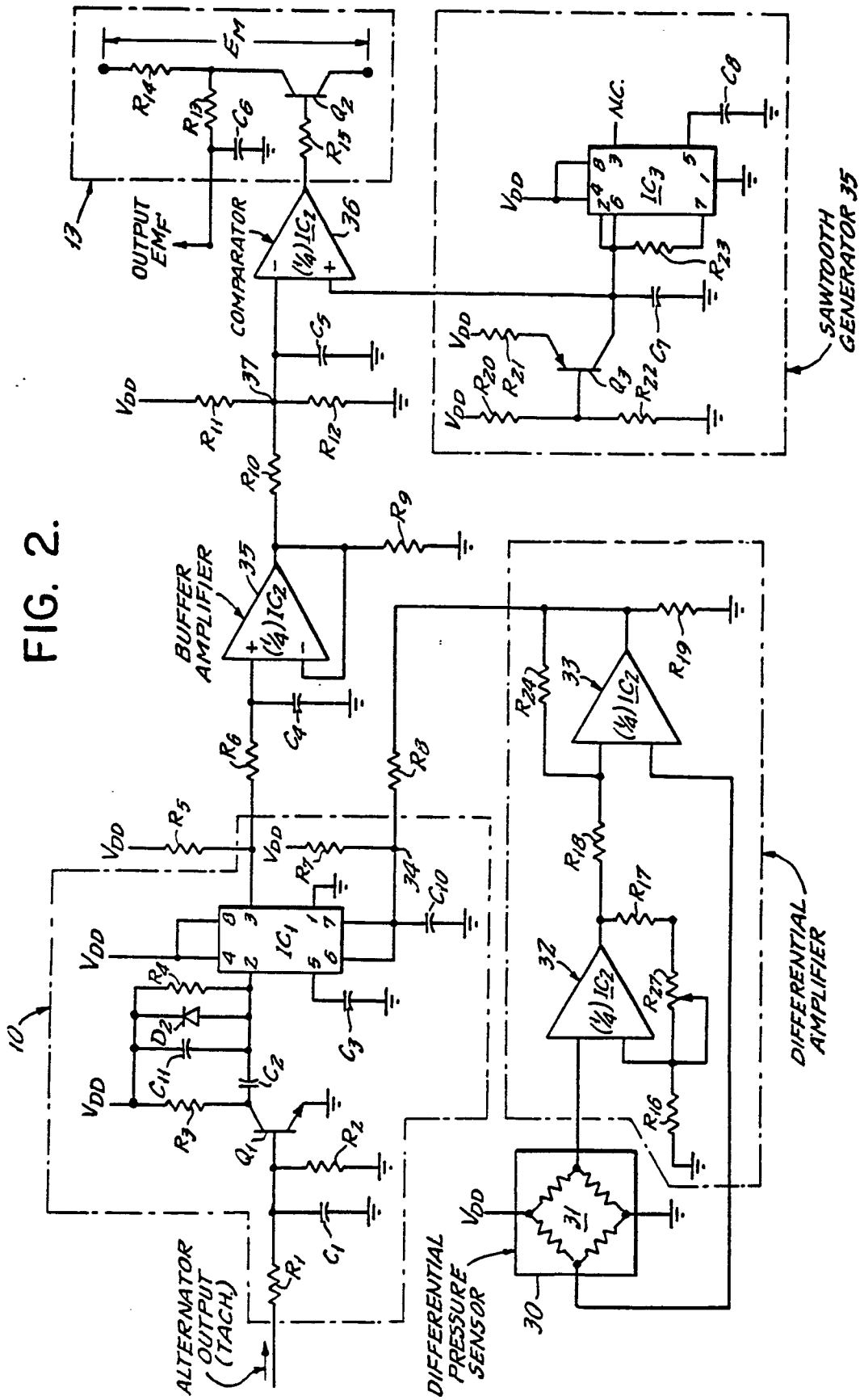


FIG. 2.