PCC EQUIPMENT - TYPE SPS 3-135 FOR MIVG

OPERATION OF STATIC CONTROL UNIT

Circuit Diagram 9 GI 52625

Measures	1 - 3
Regulator	4 -12
Adaptor	5 -18
Slip detection by ΔV	19
Slip detection by dv/dt	20
Anti-slip	20- 24
Power supplies	25 -27

The description herein applies to the equipment supplied to the MIVG. The MMTB equipment is generally similar and wherever practicable, the MMTB designations have been used. Terminal numbers, however. may differ and the MIVG numbers have been used.

STATIC CONTROL UNIT FOR PCC VEHICLES

MOTOR CURRENT MEASURE AND MONITORING

MOTOR CURRENT MEASURE

The motor current measure is produced at the output of a magnetic transductor located in the power supply panel. The transductor secondary is connected in series with the primary of the step-up transformer T3 and is fed from 24V 800Hz.

Motor current, flowing in the transductor bar, causes circulation of a proportional alternating current in the circuit formed by the secondary of the transductor and the primary of transformer T3.

The secondary of the transformer T3 is loaded by the circuit formed by resistance R16 and potentiometer R4.

The secondary current being directly proportional to the motor current, the ohmic value of R16 + R4 will determine the resultant voltage, that is, the relation between motor current and secondary voltage.

Adjustment of potentiometer R4 permits adjustment of this relationship to the desired value.

The alternating voltage thus picked up is rectified in a single phase bridge (CR4 to CR7) to be used, in negative polarity, as a motor current measure voltage.

The value of this voltage may be measured at test terminal 42 (-MsI).

COASTING MONITORING

This circuit comprises :

1 input comparator formed from resistances R19 and R20

1 operational amplifier Q3

1 control transistor Q5

The inputs to the comparator are applied at R20 by the stabilised voltage +15V and at R19 by the negative voltage of the coasting measure.

In the absence of measure voltage, the output of the comparator is positive and this polarity applied at the inverse input of amplifier Q3 has no influence on the latter.

There is no output from amplifier Q3 so transistor Q5 remains blocked.

When the negative coasting measure voltage is present, the output of the comparator is negative and that polarity applied to the inverse input of amplifier Q3 causes an output from this as a positive signal which on saturating transistor Q5 causes this latter to conduct.

Transistor Q5 on conducting allows the closing of blocking coasting comparator microrelay K3 on the acceleration regulator card.

Resistance R27 located between the output and direct input of amplifier Q3 is designed to obtain immediate closing of the electronic tumbler thus formed.

In effect, a weak negative signal appearing at the inverse input causes the appearance of a greatly amplified positive output signal which, fed back to the direct input, reinforces the action of the negative signal and thus forces closing of the tumbler.

RHEOSTATIC BRAKE MONITORING

The circuit comprises :-

Operational amplifier Q4, the direct input (3) of which depends on an external positive signal (Terminal 29 of the card) and the inverse input (2) of which is connected to the output of the input comparator;

The input comparator, formed partly from resistance R23 and partly from potentiometer R2 in series with resistance R24;

Control transistors Q6 and Q7, which control the feed to the external rheostatic brake monitoring relay (LO).

Operation

If braking is not required, terminal 29 of the card is fed with positive voltage from the control circuits and the resulting current applied to the direct input of Q4 causes a positive voltage output from this which causes transistors Q6 and Q7 to conduct and thus closes LO.

When rheostatic braking is required, the positive signal at 29 disappears and the direct input to amplifier Q4 is no longer fed. At the same time, the delay circuit formed by diodes CR25 CR24 and capacitor C9 continues to cause an output from the amplifier and prevents, as a consequence, the immediate opening of relay LO.

If, during the delay period, rheostatic braking is initiated, a negative motor current measure voltage appears at the R2 input to the comparator causing the application of a negative signal at the inverse input to Q4 which, because of this, continues to provide an output and, via Q6 and Q7, holds relay LO closed.

If on the other hand, no motor current measure signal appears, the output of the comparator remains positive and this polarity has no effect on the inverse input of amplifier Q4, which, after the delay period, will no longer provide a signal and, by blocking transistors Q6 and Q7, will cause relay LO to open.

The delay time of opening of LO is a function of the value of the capacitor C9.

The value of minimum braking current necessary to hold LO may be adjusted by the aid of potentiometer R2.

The role of the regulator is to compare the motor or coasting current instruction voltages with the corresponding measures and to provide an output voltage, the value of which will be a function of the error existing between instruction and measure and the polarity of which will determine the direction of rotation of the pilot motor.

A positive polarity output causes progression

A negative polarity output causes regression

The value of the voltage fixes the speed of rotation of the pilot motor.

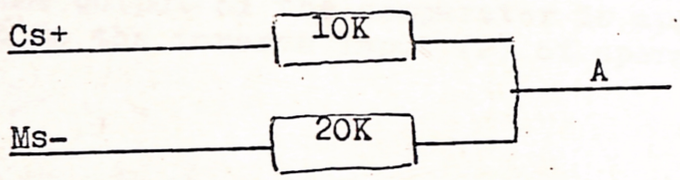
MEASURE OF ERROR

The measure of the error is obtained in an input comparator formed by means of two resistances connected together at a common point forming the output of the comparator and which receive at the other ends the instruction and measure voltages. The polarities of these voltages are always opposite.

The application of these voltages to the comparator causes circulation of a current from positive towards negative. When the algebraic sum of these currents equals zero, the output voltage of the comparator is equal to 0 V.

When the equilibrium of these currents is broken, a voltage called "error" appears at the output of the comparator; the value of this voltage is a function of the difference between the currents and the polarity equals that of the greater current.

Example



If Cs+ = +10V and Ms- = -20V $\quad i = \frac{30\,V}{30K} = 1$ mA

Voltage at A = +10V - (1MA x 10K) = 0V = equilibrium

If Cs+ = +9V and Ms- = -20V $\quad i = \frac{29V}{30K} = 0.968$mA

Voltage at A = +9V - (0,968 x 10K) = -0.68V = negative error

If Cs+ = 10V and Ms- = -19V $\quad i = \frac{29V}{30K} = 0.968$ mA

Voltage at A = +10V - (0.968 x 10K) = +0.32V = positive error

The acceleration regulator comprises 2 input comparators.

MOTOR CURRENT COMPARATOR

The positive motor current instruction voltage received at 35 is applied to the branch formed by potentiometer R2 and resistance R12. The negative motor current measure voltage received at 31 is applied at the input of resistance R4.

A third input formed by resistance R3 may eventually be used to receive a supplementary signal.

The error voltage picked up from the output of the comparator is applied via resistance R15 to the inverse input (2) of operational amplifier Q1. This amplifier produces a gain in voltage and delivers a signal of opposite polarity to that of the input signal.

The RC network formed by resistance R14 and capacitor C1 and connected in parallel with R15 produces an advance of phase allowing anticipation of the "command" from Q1 and this is the required direction.

COASTING COMPARATOR

The positive fixed instruction voltage furnished by the +15V supply potential is applied at the input of resistance R7 while the negative coasting current measure received at 29 is applied at the input of resistance R6. The error voltage picked up at the output of the comparator is applied via resistance R16 to the inverse input (2) of operational amplifier Q1.

SELECTION OF COMPARATORS

This is performed by relay K2, the coil of which is energised from 28 when the power circuits are coupled in braking or traction.

K2 de-energised (coasting)

The normally closed contact is closed and connects the output of the motor current comparator to zero potential; therefore the comparator cannot produce an error voltage output.

The normally open contact is open and the output of the coasting comparator drives the operational amplifier Q1.

K2 energised (traction or braking)

The normally closed contact is open and frees the motor current comparator output which then drives the operational amplifier Q1.

The normally open contact is closed and blocks the output of the coasting comparator to zero potential.

Note:-

Independently of the above selection, the coasting comparator may also be blocked by the normally closed contact of relay K3 of the coasting monitor.

OPERATIONAL AMPLIFIER Q1

The voltage gain across amplifier Q1 is equal to the ratio existing between the feed back resistor R18 and the input resistor R15 or R16.

In fact, the "open ring" gain of an amplifier of the type used being of the order of 45,000, we can consider that the input voltage necessary to obtain a maximum output signal is practically zero. In this case resistances R18 and R15 or R18 and R16 being fed by voltages of inverse polarity form a comparator and the algebraic sum of the currents flowing through them may be equal to zero, equality being obtained when the ratios output voltage (Vo) over R18 and input voltage (Vi) over R15 are equal.

We may write

$$\frac{Vi}{R15} = \frac{Vo}{R18} \quad \text{or} \quad Vo = \frac{Vi}{R15} \times R18$$

Zener diodes VR1 and VR2 connected in opposition across the terminals of the amplifier are used to limit the output voltage. In fact, when that voltage tends to exceed the Zener threshold of VR1 and VR2, the resulting currents not being limited by any resistance and acting in opposition maintain the excess voltage to a value practically equal to zero.

BIASSING

Because of current peaks caused by the step by step passage of the accelerator, as well as those, much more important, due to the connection of shunting, it is necessary to create a bias between the progression/regression functions to prevent "hunting". This bias is provided by the circuit comprising diodes CR5 and CR6, relay K1, resistances R9 -R10/R11 fed by a positive voltage.

If the error voltage from the comparator is positive, it is not affected by the bias circuit, and acts directly on the input to amplifier Q1.

On the other hand, if the error voltage is negative, before acting on Q1 it will be necessary to attain a value sufficient to compensate for the positive bias current passing through resistances R15 or R16.

In free coasting, current peaks being due only to the step by step passage of the coasting rheostat and the current peaks not exceeding 15%, the bias is obtained by choice of value of resistance R10/R11, fed from +15V and controlled by the normally closed contact of relay K1.

In traction or in braking, the current peaks due to the connection of shunting being much more important, a different relationship has been chosen. Since the current to be regulated differs depending on the degree of depression of the pedal, the bias circuit is in this case completed by resistance R9 placed into service by closing of relay K1 and fed by the positive instruction voltage received at 35. Since this instruction voltage determines the value of the current to be regulated, the bias voltage automatically becomes proportional to the motor current required and allows absorption without hunting of current peaks of the order of 35% of the current to be regulated.

CHOICE OF DIRECTION OF ROTATION

In braking or in coasting, if Cs+ exceeds Ms-, this signifies that the current required has not been attained. The accelerator must therefore regress. In this case, the output of the comparator being positive, the output of amplifier Q1 is negative and this polarity will therefore command regression.

On the other hand, in traction, if Cs+ exceeds Ms-, this also signifies that the current required has not been attained, but in this case the accelerator must progress. As the output polarity of Q1 remains the same as in the preceding example, it is necessary to invert it before passing it to the pilot motor regulator to obtain operation in the progression sense.

The choice of two output polarities, coasting/braking or traction, is obtained by use of amplifier Q2 and relay K4. In braking and in coasting, the signal from Q1 is passed directly to the pilot motor regulator, via the normally closed contact of K4. In traction, relay K4 being excited, the normally closed contact is open and the signal provided by Q1 passes to the inverter amplifier Q2 which reverses its polarity. The output of Q2 then feeds the pilot motor regulator by way of the normally open contact of K4.

Resumé

	Polarities				Direction of rotation of motor
	Comparator output	Q1 output	Q2 output	Pilot motor reg. input (J7)	
Braking/coasting					
If Cs+ > Ms-	positive	negative	-	negative	Regression
Cs+ = Ms-	0	0	-	0	Stop
* Cs+ < Ms-	negative	0	-	0	Stop
Cs+ < Ms-	negative	positive	-	positive	Progression
Traction					
If Cs+ > Ms-	positive	negative	positive	positive	Progression
Cs+ = Ms-	0	0	0	0	Stop
* Cs+ < Ms-	negative	0	0	0	Stop
Cs+ < Ms-	negative	positive	negative	negative	Regression

* indicates that the error between Cs+ and Ms- is in the bias zone.

PILOT MOTOR REGULATOR

In order to be able to regulate the speed of rotation of the pilot motor, taking into account the differences of motor effort necessary during the passage of steps of the accelerator, the signal coming from the acceleration regulator is completed by a signal giving an image of the current circulating in the armature of the pilot motor.

This arrangement compensates for the IR loss in the armature and allows the acceleration regulator signal, whatever the effort necessary, to regulate the electromotive force of the pilot motor in a manner to obtain a speed of rotation practically proportional to the value of the signal.

The armature current measure is obtained by two resistances connected between the negative progression/regression outputs of the power amplifier and zero potential.

The voltage drop, image of the armature current, measured in this fashion is therefore positive with respect to the same zero potential.

The positive measure voltage, raised in progression, is directed across resistance R34, the direct input to amplifier Q4, which delivers a proportional voltage of the same polarity.

The positive measure voltage, raised in regression, is fed across the resistance R33, the inverse input to amplifier Q4 which delivers in this case a voltage, again in proportion, but of inverse polarity.

The polarity of these voltages is the same as that provided by the acceleration regulator i.e. positive for progression, negative for regression.

The signal from the acceleration regulator is fed to the inverse input to amplifier Q3 via resistance R29. This signal is complemented by that compensating the IR loss which, of the same polarity, similarly feeds the input to Q3, via resistances R30 and R31.

The sum of currents flowing in these two branches determines the corresponding output voltage from Q3.

Potentiometer R30 allows the influence of the IR compensation to be adjusted.

The pilot motor regulator is completed by a current limiter, functioning as follows:-

The pilot motor current measure voltage is also applied to the direct entry of amplifier Q3 but across the Zener diodes VR3 VR4 and resistance R32.

The action then, the polarities being the same, is inverse to that at the inverse input.

This means that when the current flowing in the pilot motor provides an output voltage from Q4 greater than the threshold of the Zener VR3 or VR4 (depending on polarity), intervention occurs via the direct input to Q3 tending to cancel the action of the voltage applied at the inverse input.

The gain of the limitation loop being high, a small excess of current to be limited has a marked effect on the output voltage of Q3, allowing the required limiting value to be obtained with great precision.

The output voltage of amplifier Q3 represents the output signal of the acceleration regulator and is used to control the 40V 3amp adaptor card J2.

DELAY OF BRAKING REGULATION

The circuit formed by transistors Q5 and Q6 and their control elements is intended to delay passage of the regulator to braking current regulation when the speed of the vehicle is below 12 mph (18km/h).

Operation

The lead connected to 19 is energised by closing one of the braking contactors.

If terminal 20 is also energised at that moment, transistor Q6 conducts and battery voltage is initially applied across resistance R51, preventing unblocking of Q5 and consequently the passage of the brake command signal to the regulator micro-relays.

Capacitor C19 charges and the voltage at the terminals of R51 falls until it attains a value low enough to unblock Q5. The latter, becoming conducting, applies voltage to terminal 18 and the regulator then passes to braking regulation.

Furthermore the collector of Q5 having become positive, transistor Q6 is blocked and capacitor C19 discharges through resistance R52.

The value of C19 has been chosen to obtain a delay of 0.5 second. Capacitor C20 connected between emitter and base of Q5 delays very slightly its conduction in order to allow Q6 to operate first in the event that both transistors are placed under voltage simultaneously.

If terminal 19 only is energised, transistor Q6 remains blocked and since no voltage is applied across R51, Q5 unblocks and assures immediate feed to terminal 18.

POWER SUPPLY + and - 15V

This stabilised power supply is formed on the card by the circuit comprising R43, R44 and VR5 for -15V and by circuit R48, R45 and VR6 for +15V.

LIMIT SWITCH SUPPLY CIRCUIT

This circuit is formed by resistances R46, R47, R49 and capacitors C17 and C18 and supplies to terminals 14 and 16 the voltages necessary to operate the blocking circuits of the 40V 3 amp adaptor supplying the pilot motor.

CONTROL OF BRAKED COASTING

The normally open contacts of micro-relay K3 are used to control an auxiliary relay CCR external to the static control unit, which, in the case of failure of free coasting, causes :

(a) in series traction - automatic transition to series parallel

(b) in free coasting - passage of the equipment to minimum rheostatic braking (braked coasting)

STATIC CONTROL UNIT FOR PCC VEHICLES

40V 3 amp adaptor

The 40V 3 amp adaptor is an amplifier destined to provide the necessary power to feed the pilot motor armature. The value and the polarity of its output signals are functions of the state of the input signal provided by the accelerator regulator card.

Variation of the mean output voltage is obtained by the variation of the time of conduction of the power transistors controlling the supply to the load; its value is proportional to the value of the input voltage.

The amplifier includes two control chains:

The first reacts to a negative input signal and includes:

Switching circuit No. 1
The feed transformer to the bases of the power transistors (T1)
Two power transistors Q18 and Q19
Two protection diodes CR23 and CR24
A blocking circuit (Terminal 3)

This chain is used to control the progression sense of rotation.

The second chain reacts to a positive input signal and includes:

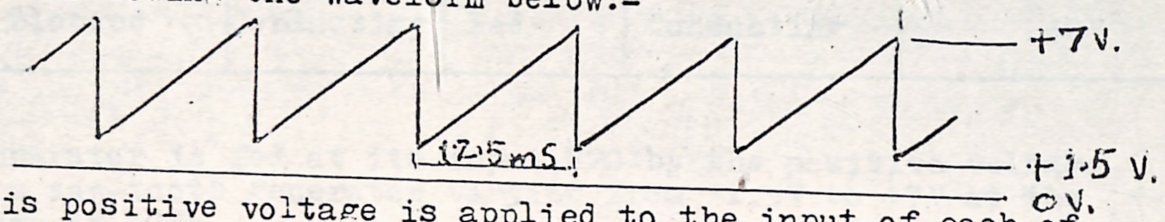
An amplifier to invert the input polarity
Switching circuit No. 2
The feed transformer to the bases of the power transistors (T2)
Two power transistors Q20 and Q21
Two protection diodes CR25 and CR26
A blocking circuit (Terminal 7)

This chain is used to control the regression sense of rotation.

The part common to both chains comprises:

A 2Khz oscillator intended to provide the energy necessary to feed transformers T1 and T2.
This feed is controlled in each chain by transistors Q16 and Q14 of the switching circuits.

A saw-tooth voltage generator intended to form a positive voltage varying from +1.5V to +7V at a frequency of 80Hz and following the waveform below:-



This positive voltage is applied to the input of each of the two switching circuits.

OPERATION OF CHAIN 1 (Progression)

To make the power transistors Q18 and Q19 conduct and hence to feed the pilot motor armature, it is necessary to cause the current provided by oscillator transformer T3 to circulate in the primary of T1.

The voltages induced in the two secondaries of T1 then feed the bases of the two power transistors Q18 and Q19 which conduct and feed the armature through the circuit B+, terminals 8-9-10, Q18, terminals 14-15-16, M+ lead, M- lead, terminals 25-26-27, Q19, terminals 31-32-33, progression current measure resistance, 0V.

For the power current to circulate in the primary of T1, the output transistor, Q14, of the switching circuit must be conducting.

On examining the switching circuit, we see that if the output voltage of the comparator (formed by resistances R18, R19, R20) is positive, transistor Q9 is conducting which blocks transistors Q12 and Q14.

On the other hand, if the output voltage of the comparator is negative, transistor Q9 is blocked and transistors Q12 and Q14 become conducting.

Comparator output polarity	Transistor Q9	Transistors Q12 Q14	Primary Trans. T1	Transistors Q18 Q19	Pilot motor input voltage
+	Conducting	Blocked	Not fed	Blocked	0V
-	Blocked	Conducting	Fed	Conducting	40V

The comparator is fed at its input R20 by the positive voltage from the saw-tooth generator varying from +1.5V to +7V at the frequency of 10Hz.

Input R19 of the comparator is fed by the control voltage from the pilot motor regulator (J6), capable of varying between +10V and -10V.

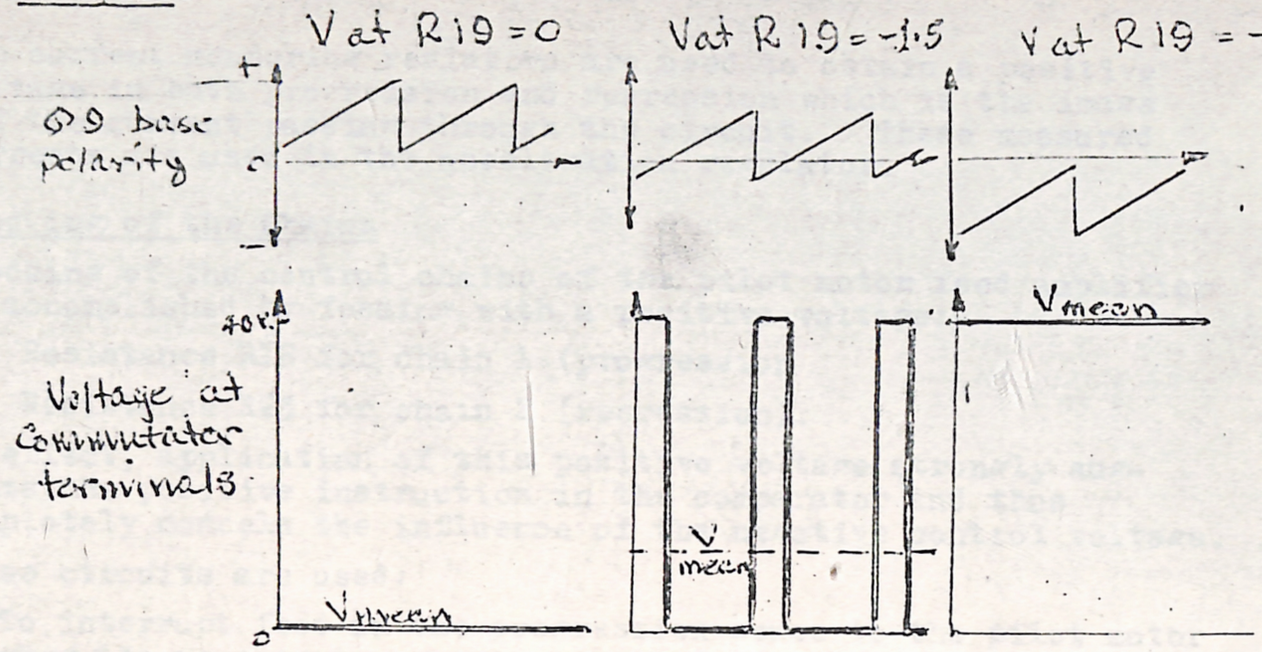
In considering the characteristics of the switching circuit, it is necessary to apply at R19 a negative voltage of the order of -0.4V in order to make transistor Q14 conduct when the positive voltage on R20 is +1.5V

Variation of the control voltage over the range +10V to -0.4V therefore has no action on this control chain. That action begins when the control voltage falls below -0.4V, blocking transistor Q9 for a period the length of which is proportional to that voltage.

Remember that blocking Q9 causes conduction of the power transistors and that the time of conduction of these transistors determines the mean voltage at the terminals of the load.

A control voltage of -10V applied at R19 completely cancels the effect of the positive voltage applied at R20 and therefore causes the application of the maximum voltage to the terminals of the load.

Examples:



The chain is blocked by applying a positive voltage at the input to resistance R19, which has the effect of strongly augmenting the positive instruction in the comparator thus completely cancelling the influence of the negative control voltage.

Operation of Chain 2 (regression)

Contrary to chain 1 which reads only to a negative control voltage, chain 2 reacts only to a positive control voltage.

This difference is obtained by causing the control signal in this case to pass through a polarity inverting circuit which controls switching circuit No. 2.

From this point onwards the operation of the two chains is identical and a control voltage of +0.4 to +10V, after polarity inversion, controls switching circuit No. 2 and in this case causes conduction of the power transistors Q20 and Q21.

The pilot motor armature is thus fed in the regression sense from the circuit B+, terminals 11-12-13, Q20, terminals 22-23-24, M-lead, M+ lead, terminals 20-21, Q21, terminals 28-29-30, regression current measure resistance, 0V.

The current measuring resistors are used to obtain a positive voltage in both progression and regression which is the image of the current passing through the circuit. These measured currents are used in the acceleration regulator.

Blocking of the Chains

Blocking of the control chains of the pilot motor feed amplifier is accomplished by feeding with a positive voltage:-

Resistance R18 for chain 1 (progression

Resistance R23 for chain 2 (regression).

In effect, application of this positive voltage strongly augments the positive instruction in the comparator and thus completely cancels the influence of the negative control voltage.

These circuits are used:

To interrupt feed in the progression sense to the pilot motor when the accelerator reaches the end of progression travel (chain 1)

To interrupt feed in the regression sense to the pilot motor when the accelerator reaches the end of the regression course (chain 2)

To interrupt feed in both progression and regression sense to the pilot motor in case of axle slip (Chains 1 and 2)

To do this, resistances R18 and R23 are permanently fed from two positive voltages supplied from the acceleration regulator card. In the absence of any other intervention, the amplifier is thus blocked in the two directions of operation.

Unblocking of the chains is obtained by connection to zero potential the input to resistance R19 for the progression chain and the input to resistance R23 for the regression chain.

This is done by connecting circuit K to the progression limit switch and circuit L to the regression limit switch of the accelerator and the common output KL of the two to the normally closed contact of the anti-slip relay K1 in J13.

The other terminal of this contact is at 0V potential.

Operation

Anti-skid relay K1 is not excited and its contact is closed.

If the accelerator is at position 1, its progression limit switch is closed, lead K is at 0V potential and since resistance R18 in this case is not fed by +40V, chain 1 is unblocked and the amplifier can, under the control of the regulation, feed the pilot motor in the progression sense. On the other hand, the regression limit switch of the accelerator being open, lead L remains at +40V potential and chain 2 remains blocked. The amplifier therefore cannot feed the pilot motor in the regression sense.

If the accelerator is at an intermediate position, both limit switches are closed, wires K and L are at 0V potential, both chains are free, and the amplifier can, under control of the regulation, feed the pilot motor in either progression or regression sense.

If the accelerator is at maximum position, its progression limit switch is open, lead K is at +40V potential resulting in blockage of the progression chain

If the accelerator is in any position at all and the anti-skid relay K1 is energised, its normally closed contact opens.

The connection of leads K and L to zero potential thus being interrupted, these return to +40V potential and in this case, block the function of both control chains.

The accelerator therefore is immobilised in the position occupied at the moment of operation of the anti-slip. Blocking of the accelerator by interruption of circuit KL may also be used in certain equipment during transition between series and series - parallel coupling.

STATIC CONTROL UNIT FOR PCC VEHICLES - Slip Detection through ΔV

The slip detection card comprises two identical circuits each controlling one motor branch.

Supply isolation of each circuit is ensured by a transformer, the primary of which is fed with 24V 800Hz and each of the secondaries of which, after passing through a single phase rectifier bridge, supplies +22V to the corresponding detection circuit. This +22V supply permits in its turn the formation of + and - 15V through the operation of circuit R13-R14-VR7 and VR8 on the one hand and R33-R34-VR27 and VR28 on the other.

Slip is detected by comparing the voltage appearing at the centre point of the two armatures with the voltage obtained at the centre point of a group of resistances connected as a voltage divider bridge across the terminals of the same armatures.

The central portion of the divider bridge is a potentiometer, the adjustment of which allows compensation for the differing magnetic characteristics existing between motors and for eventual differences between wheel diameters. The divider bridge is completed by two filter condensers intended to absorb the voltage peaks caused by motor commutation.

The centre point of the motors is connected to the zero potential point of the equipment while the centre point of the divider bridge is connected to the inverse input of amplifier Q1.

In normal operation no potential difference exists between the two measures. In the case of slip, however, unbalance occurs and the potential difference obtained appears at the inverse input to amplifier Q1.

The high gain of the latter allied with a feedback circuit comprising resistance R10 acting on the direct input has the effect of making it produce its maximum voltage. This voltage, depending on polarity, saturates one of the transistors Q2 or Q3, which, becoming conducting, feeds a micro relay.

Energisation of this relay causes its normally open contacts to close and sends a slip logic signal to the anti-slip circuit.

The point of operation of the equipment, that is, the voltage difference between the two inputs necessary to cause closing or opening of the micro relays is determined by the value of desensitising resistors R5, R6 and R8.

SLIP DETECTION BY DV/DT

(Described but circuit diagram not included in 9 GI 52625)

During braking, the circuit detects any too-rapid drop of voltage between terminals of two motors in the same group.

The detection card comprises two identical circuits each controlling one group of two motors.

OPERATION (Group 2)

The terminal voltage from two armatures in series is applied:-

in negative to terminal 3 of the FL2 block, that is, to the zero potential point of the detector

in positive to terminal 1 of the FL2 block, but across an RC group formed by resistance R4 and capacitor C2

When the voltage appears and increases at the terminals of the motors, capacitor C2 charges through the circuit R4-C2 and the Zener diode VR1, which in this direction acts as a diode. The positive voltage raised at point 1 therefore does not exceed about 1 volt.

If on the other hand, the voltage drops, the capacitor discharges and a negative voltage appears at point 1. The value of this negative voltage is a function of the value of the RC group and the rapidity of the voltage drop at the motor terminals.

The negative measure voltage is passed by Zener VR1 and carried to terminal 7 of the detection card. The RC group formed from R2/C1 and R3/C2 is intended to filter the measure signal.. The electronic tumbler formed from amplifier Q1, transistor Q2 and micro relay K1 is polarised so that it will not react under the control of a negative signal.

The threshold of operation is fixed by the desensitising circuit formed by resistors R6-R8 and diodes CR3, CR4, CR5, and CR6.

Potentiometer R3 in series with the input signal allows adjustment of the operating voltage to the desired value.

The contact of microrelay K1, closing if slip is detected, passes a logic control signal to the anti-slip card. Feed of the logic signal being ensured only in braking, the dv/dt slip detection circuit is inoperative during traction coupling.

STATIC CONTROL UNIT FOR PCC VEHICLES - ANTI-SKID

The operation of this card is to produce in case of operation of the slip detector:-

1. direct blocking and unblocking of the pilot motor rotation
2. holding auxiliary relay LO energised
3. direct energising and timed de-energising of the sanders
4. during braking only, the timed energising and direct de-energising of the track brakes

These different actions are commanded by the slip logic signal sent by the detection card or cards. The voltage of the signal before exciting certain parts of the circuit, is held to +24V by the intervention of resistance R14 and Zener diode VR2. The indicator lamps, each fed by a signal from the detector, allow verification for each motor group of the type of slip detected.

1. Blockage of pilot motor
   The supply of any one of the slip logic signals energises the coil of relay K1 which closes immediately.
   The normally closed contact (terminals 5 and 9) of this relay opens and thus acts on the blocking circuits of the amplifier feeding the pilot motor. This cuts supply to the pilot motor, causing the accelerator to stop at the position occupied at the moment of slip detection. Disappearance of the slip signal causes immediate re-opening of relay K1, the normally closed contacts of which on reclosing stop blockage of the accelerator and allow once again positioning of this latter under the control of the acceleration regulator.

2. Auxiliary relay LO

   The same relay K1 when energised closes its normally open contact (terminals 7 and 11) and feeds the coil of the lockout relay thus causing or maintaining its closure independently of the rheostatic brake monitoring circuit.

   This action has the effect of holding back application of the drum brakes pending a skid.

3. Sanders

The slip signal at the same time:-

directly feeds the gate of Thyristor TH1 via diode CR5 and the 100 ohm resistor R5. This conducts and allows the direct energisation of the sanders through output 31-33-35 (point A);

unblocks transistor Q3, which, via diode CR6 and Q3, carries point C and consequently the base of uni-junction transistor Q2 to zero potential and holds it blocked. Then appearance of a positive potential at point A unblocks transistor Q1 which conducts and resets connection B to zero potential. The uni-junction Q2 being blocked by transistor Q3, this change of potential at B has no immediate effect.

When the slip signal disappears, Thyristor TH1 remains excited by its circulation current but on the other hand the base of transistor Q3 being no longer fed this latter blocks itself and frees the base of uni-junction Q2.

The battery voltage received at terminals 1 - 3 of the circuit is then applied across the RC circuit formed by resistance R13 and condenser C4. After a time, determined by the ohmic value of R13 and the capacity of C4, the voltage across the capacitor reaches the threshold of conduction of the uni-junction transistor and in unblocking it sends a current impulse through the primary of transformer T1.

This impulse is transmitted by the secondary of T1, to the gate of the extinction Thyristor TH2 which on becoming excited causes through the intervention of capacitors C2 and C3 delayed extinction of Thyristor TH1. This cuts off, the sander is no longer fed and point A returns to zero potential; transistor Q1 blocks and interrupts the passage of current in Thyristor TH2 which extinguishes in its turn.

The circuit is thus ready for a new cycle of operation.

4. Track brakes

As already described, the appearance of a slip signal has the effect of immediately unblocking transistors Q1 and Q3 and carrying points B and C to zero potential.

Point C being at zero, transistors Q4 and Q5 are blocked. The slip signal voltage is thus applied to the terminals of an RC group formed by resistance R25 and condenser C6.

After a time determined by the value of the RC group the voltage across condenser C6 reaches the threshold of conduction of the uni-junction transistor Q6 and in unblocking, this sends an impulse of current through the primary of transformer, T2.

This impulse is transmitted via the secondary of T2 to the gate of Thyristor TH4 which on excitation provides delayed application of voltage to terminal 27. This signal appearing at 27 is used during braking for the delayed control of the track brakes.

When the slip signal disappears, transistor Q3 in unblocking returns point C to potential +40V. Transistor Q4 is thus unblocked and allows feed to the gate of extinction Thyristor TH3 which on excitation causes through the medium of capacitor C5 direct extinction of Thyristor TH4.

TH4 being cut off, the control of the track brakes is interrupted.

At the same time, point C being raised to potential +40V has caused unblocking of transistor Q5 which on conducting instantaneously discharges condenser C6. This latter is thus ready to recommence directly its timing cycle.

After the sander feed voltage disappears transistor Q1 blocks and interrupts the passage of current in Thyristor TH3 which extinguishes in its turn in the same manner as Thyristor TH2

Note

A capacitor of 0.1 uF placed between the gate of Thyristor TH1 and point A protects TH1 against unwanted excitation due to voltage peaks caused by the closing of contactors.

STATIC CONTROL UNIT FOR PCC VEHICLES - POWER SUPPLY

1. Formation of 24V 800Hz

This voltage, supplied by the secondary of transformer T1 (terminals 7 and 10) is formed by a transistor vibrator powered from battery voltage.

Operation

On applying voltage to the vibrator, the battery voltage is applied :

- on one hand to terminal 4 of T1, but since transistors Q2 and Q3 are blocked no current flows in the windings;
- on the other hand, to the emitter of transistor Q1 and across R1 to the base of the same Q1

Condenser C1 not yet being charged following the application of battery voltage and during the time of charge of C1, the base of Q1 is negative and the unblocked transistor applies, via R2, T1 3-12 and CR1 a positive voltage to the base of transistor Q2. This, unblocked, allows in its turn passage of current in the sense 4-1 in the primary of T1. The emf. thus induced, in the sense 3-12 of the secondary of T1 reinforces the base current of Q2 and gives this its normal operating value which is a function of the secondary voltage of T1 and the value of R5 + R6. During this time, condenser C1 having charged to the positive potential, transistor Q1 blocks and is rendered inoperative.

Transistor Q2 remaining unblocked, the current established in the branch, resisted at the beginning by the self-inductance of transformer T1, reaches the saturation value for this self inductance and suddenly tends to increase.

At this moment, the value of the current able to circulate in the sense collector - emitter of Q2 being limited by the fixed value of base current, this transistor retains across its terminals the greater part of the supply voltage and the voltage across the primary of T1 becomes practically nil. The voltage induced in the secondary 3-12 of T1 disappears and transistor Q2 cuts off.

Q2 having cut off, the energy stored in the self inductance of T1 is restored in part in the sense 3-2 of the secondary of T1. This unblocks Q3, establishes current in the sense 4-5 of the primary of T1, induces in the sense 3-2 of T1 current in the base of Q3 and recommences the process of blocking and unblocking described above.

The secondary of T1 (terminals 7 and 10) is similarly the seat of an induced e.m.f. and supplies the 24V 100Hz used by the regulator. This winding restores, also, part of the energy stored in the self-inductance of T1 and given up at the moment Q2 or Q3 is blocked.

If the load at the terminals exceeds a determined value, the importance of this restoration of energy is such that its reduction prevents that operation by the secondary 3-12 or 3-2 from attaining a sufficient value to unblock the transistor in control, and, as a consequence, stops the vibrator, which is thus self-protected against over-load or short circuit. The value at which this occurs may be adjusted by potentiometer R6.

Notes:

After the vibrator stops there is a waiting period of two to three seconds before it can restart. In fact, it is necessary to await the discharge of the starting condenser C1 through the circuit +C1-R7-R1-R10 and -C1.

When starting the vibrator, the unblocking of Q1 causes application of the positive voltage to the bases of two transistors Q2 and Q3. The differentcharacteristics necessarily existing between two transistors decides which one of them will unblock before the other.

The description given above supposes that it will start with transistor Q2.

2. Formation of Direct Current Voltages

+40V

The +40V supply used in the regulator is provided directly from the battery voltage across a fuse F1

-40V

Transformer T2 fed at the primary by 24V 800Hz delivers at the secondary an 800Hz voltage which after rectification by the diodes CR12 and CR14 forms with respect to the centre zero point a -40V potential.

+24V and -24V stabilised

The voltages + and -40V applied to R11, R12 and VR11 on the one part and to R13 and VR12 on the other part provide stabilised + and -24V potentials.

Capacitors C11, C12, C13 and C14 are the filter capacitors.

A micro relay, the coil of which is fed by -24V, verifies the presence of the feed voltages and intervenes in the case of de-energisation of the control circuits of the vehicle.

The + and -40V supply is used in the acceleration regulator card to form the + and -15V stabilised supply necessary for its operation. The + and - 24V stabilised supply is used in the 40V 3amp adaptor for the feed of the pilot motor.

The 24V 800 Hz is used to supply the motor current measure circuit as well as the feed to the slip detector card.

Note:

The +40V supply intended for the regulator passes through the normally open contact of the monitoring micro relay so as to avoid the application of only one of the voltages +40V or -40V.