

[54] **REMOTE CONTROLLED MINIATURE-VEHICLE**

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8, 1969, abandoned.

[30] **Foreign Application Priority Data**

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180/79.1

[51] Int. Cl.....**A63h 33/26**

[58] Field of Search 180/2, 79, 79.1; 104/149;

46/244 R, 244 A, 243 E; 191/2, 3; 273/86 R,
86 B

[56]

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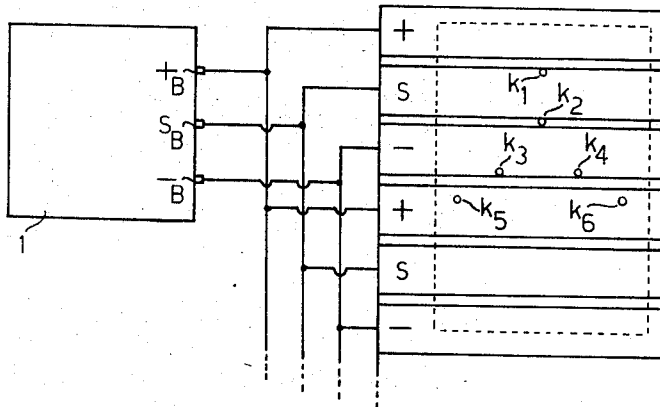
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[57]

ABSTRACT

A system for remote control of objects moving freely on a surface includes solutions for transmitting power and remote control signals to objects without power amplification of signals. In connection with the system may be used several modes of transmission of information.

4 Claims, 9 Drawing Figures



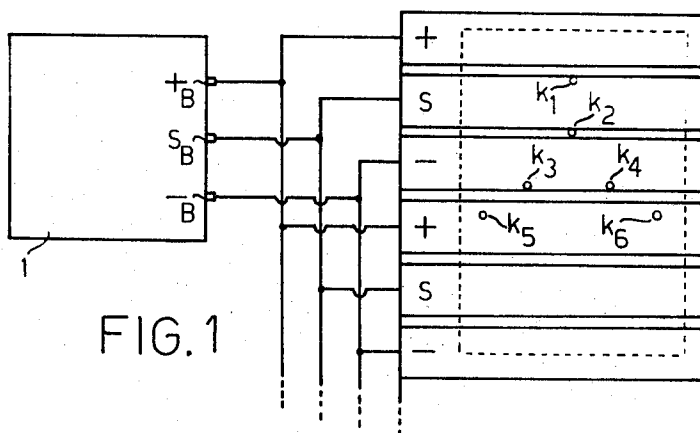


FIG. 1

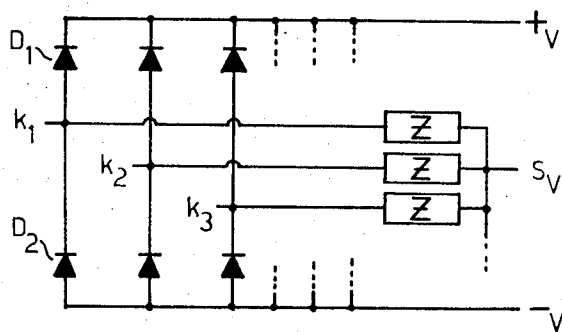


FIG. 2

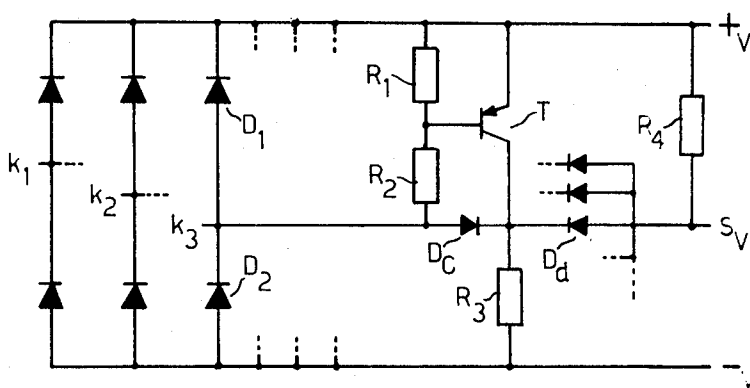
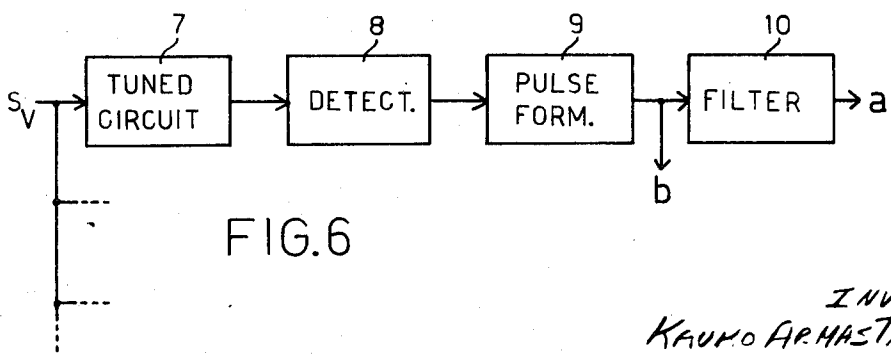
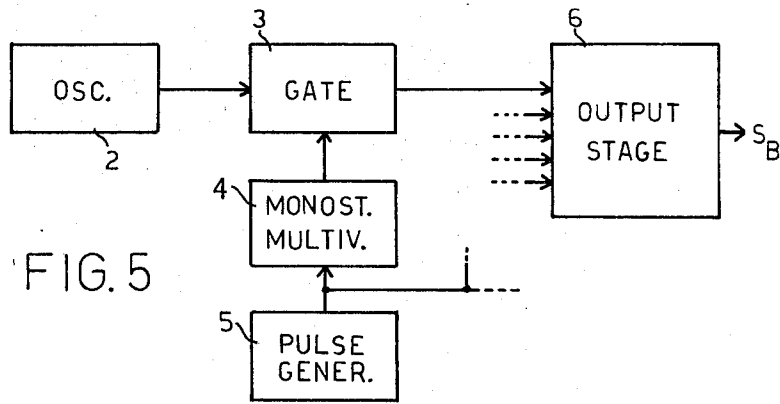
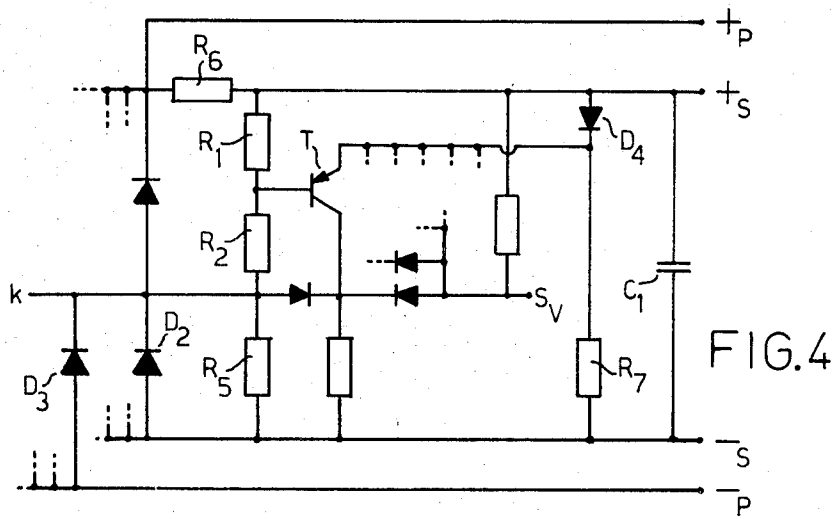


FIG. 3

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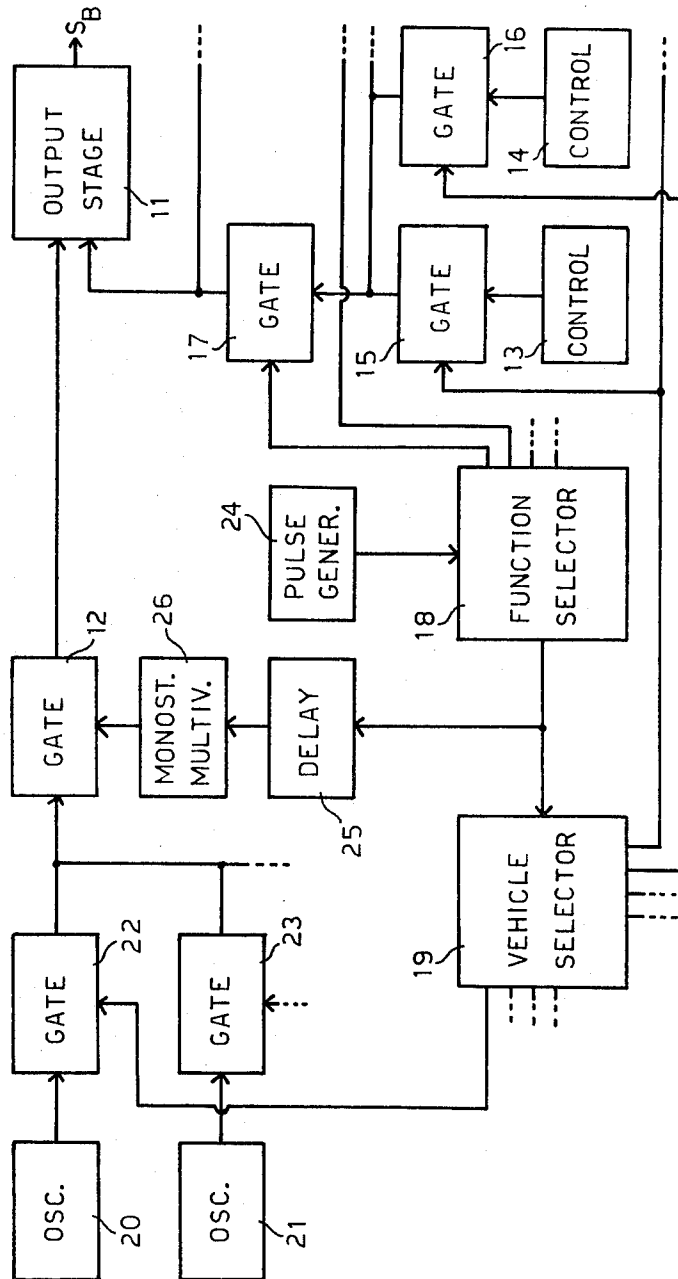


FIG. 7

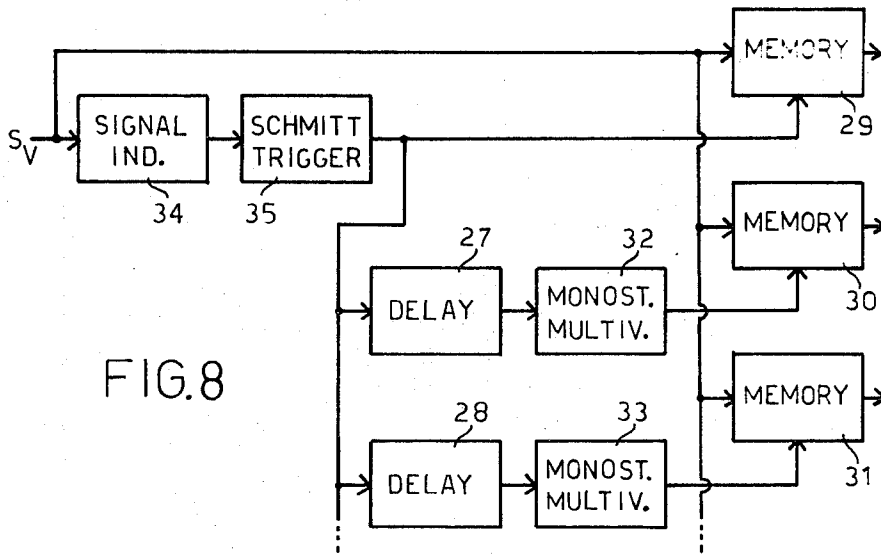


FIG. 8

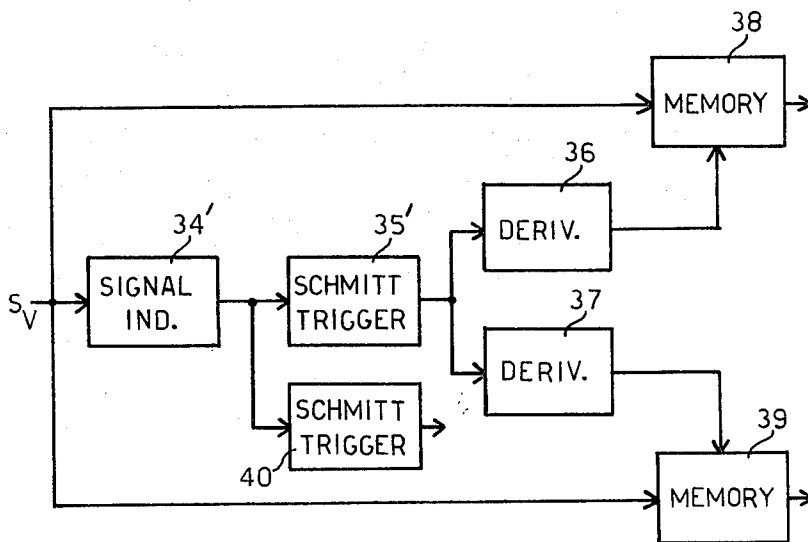


FIG. 9

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REMOTE CONTROLLED MINIATURE-VEHICLE

This application is a continuation-in-part application of my copending application Ser. No. 789,853 filed Jan. 8, 1969, entitled "Remote Controlled Miniature Vehicle System, now abandoned."

This invention relates to remote control of miniature vehicles which receive electric power and remote control information from a driving surface which is equipped with conducting material elements. The principal scope of use are pastime, testing and teaching purposes, which may require several remote controlled objects moving freely on a surface in any direction independently of one another.

Earlier there have been introduced solutions for car-tracks in order to render possible that a vehicle could be steered as well as having its driving speed regulated. The earliest of these solutions are, however, of the kind that they are in principle fitted for the use of only one or two cars. Later there were introduced solutions which were still designed in the first place for use of one or a few vehicles, but their principle could be at least theoretically considered for use even within the frame of a broader system. In those solutions the driving surface is equipped with two groups of metal strips. Between these groups a supply voltage is applied which is superimposed by control signals which may be frequencies specific to each control function. The vehicles are furnished with contacts for receiving electricity from the track, these contacts being arranged so that at any one moment at least one contact touches each group of strips. The inconvenience of such a solution is that the remote control signals have to be power-amplified, which thereby makes great demands on the output stage feeding the track especially considering that the rotating motors of the vehicles tend to cause disturbances in the signal.

When broadening a system by adding vehicles and control functions several factors cause difficulties simultaneously: total current consumption increases, the required frequency spectrum widens and maximal signal level of each control activity must be reduced because the sum signal must be kept within certain limits. If, on the other hand, for eliminating the last mentioned trouble, carrier waves specific to each vehicle are used, which are modulated by frequencies specific to different functions, the carrier waves would be selected so high that the realization of the power stage would introduce further more difficulties. The effect of disturbances would become most serious in cases when the vehicles included a feedback servo system, e.g., for steering purposes, because disturbances would make the servo system unstable. Furthermore, regarding switchings which have suggested in connection with earlier solutions, it has to be assumed that the rectifier elements used in connection of contacts are so fast that they are able to transmit the frequencies used.

The present invention can be applied even in connection with a very broad system containing a great number of moving objects and several control functions for each object, as well as for control of other than speed and steering.

According to the present invention electric power and signals are transmitted through different groups of elements on the surface and thus power amplification of signals can be avoided. Two groups of elements are

used for transmitting power and other groups for transmitting signals. When signals are kept as for their direct voltage level between the two levels of the power supply, power supply can be separated from signals. If the surface is equipped with several groups of elements for transmission signals, signals of each group may be on individual direct voltage level for separation of different signal groups.

In the preferred embodiment of the invention the surface is equipped with three groups of elements, two groups for transmitting power and the third group for transmitting signals. When the vehicles are equipped with contacts so arranged that in every situation each group of elements of the surface is touched by at least one contact of each vehicle, the vehicles can move in any direction on the surface. The contacts have to be equipped with an input circuit which consists of rectifiers for sending incoming supply voltages into supply voltage points, which in turn feed electronic circuits and power devices of the vehicle, and circuits for sending incoming signals into a special signal point, which is coupled to the input point of signal receiving circuitry.

Circuits between contacts and the signal point may consist of pure impedances when potential in the signal point would be weighed mean value of potentials of different contactors or of gate circuits which send signals to the signal point and blocking effect of supply voltages to the said point, the separation being based upon different d-c levels. In a general case when the surface consists of m groups of elements, in which two groups are for transmitting power and $m-2$ groups are for signals, it is advisable to arrange transmission of information so that all information to each vehicle is transmitted through a certain signal group of elements. Therefore, the gates of each vehicle are planned to receive signals only from a certain signal group of elements. When the signals of each group of elements are kept within certain d-c limits, limits of different groups being non-overlapping, separation of signals of different groups can be carried out by means of gates.

By transmitting power and information through separated groups of elements on the surface, power amplification of signals can be avoided and the effects of disturbances caused by power devices are effectively eliminated. In a broad system including a great number of moving objects, total current consumption would be high, which would make use of this invention advantageous. A further advantage of this invention is that it is very versatile as for the mode of information transfer. So it is possible to use a frequency division or a time division principle or any combination of these for differentiating between several orders involved with the system. The general m -group system presented before can be regarded as a use of a space division principle based on structures, on the base unit and on the surface. Information may be transferred in analog or digital form. Transmission of values of orders may be based on amplitude-, frequency- or phase-angle modulation or on different pulse modulations. In addition, in connection with time division or space division principles, it is possible to use direct voltage levels for transmission of information. The most advantageous way of information transfer may be different in different cases, depending on the number of objects, the number of

control functions, the demands for accuracy in information transfer and on factors as price, need for space, etc. In simplest cases the use of a pure frequency division principle would be advantageous because then transmission of information could be continuous and no memory circuits are needed in the vehicles for storing information. An efficient elimination of disturbances and versatility as for mode of information transfer makes possible that the invention can be adapted also to very broad systems.

A further advantage of this invention is that it makes possible an efficient and reliable feeding of information from the vehicles to the base unit feeding the surface. This kind of possibility would be important in certain special adaptations of the invention. This can be accomplished so that an oscillator situated in an object is coupled to the input circuit of said object so that it causes current consumption variations of a certain frequency into the base unit. If these variations are fed into that part of the base unit that is feeding signal elements to the surface, the transmission of information can be effected with a relatively low power consumption and it is possible to give reliable and short mark signals and to transmit mark signals at any moment. In connection with a prior art system of two groups of elements, the transmission would require essentially more power and even then transmission of short signals might be unreliable because of disturbances caused by power devices.

The detailed description is accompanied by the following drawings:

FIG. 1 is a schematic diagram illustrating the relation of a base unit, a surface and an object on it.

FIG. 2 is a circuit diagram presenting an input circuit of an object where contacts are coupled to a signal input point by means of impedances.

FIGS. 3-4 are circuit diagrams presenting input circuits of an object where contacts are coupled to a signal input point by means of gate circuits.

FIG. 5 is a block diagram presenting circuits of a base unit in the case of transmitting signals with the aid of a frequency division principle and by using a pulse duration modulation.

FIG. 6 is a block diagram presenting circuits of an object in the case according to FIG. 5.

FIG. 7 is a block diagram presenting circuits of a base unit when transmitting information with the aid of d-c levels by means of a time division principle.

FIG. 8 is a block diagram presenting circuits of an object in the case according to FIG. 7.

FIG. 9 is a block diagram presenting circuits of an object in a modified case of FIG. 8 when only two orders of analog form and one of on-off form are received.

In FIG. 1 there is a schematic presentation of the case where the surface is equipped with three groups of elements, which in practice may be parallel metal strips. Two groups (+, -) are connected to the corresponding power outputs (+_B, -_B) of the base unit (1) feeding the surface. The third group (s) is connected to the corresponding signal output (s_B). Moving objects may be equipped with contacts (k₁-k₆), which are arranged so that in every situation each group on the surface is touched by at least one contact. The d-c level of signal remains always between the levels of +_B and -_B.

No other restrictions are put to the signal; it may be an a-c signal superimposed on a fixed d-c level or it may contain also a d-c component or it might also be composed of pure d-c pulses. The contacts have to be equipped with input circuits to lead supply voltages into corresponding supply voltage points of objects and to lead a signal into the signal point which is connected into the input of signal receiving electronic circuitry.

In FIG. 2, there is shown one possible input circuit for vehicles associated with the contacts. In this circuit, each contact (K₁, k₂, k₃) is connected with rectifiers (D₁, D₂) which lead into the positive and negative supply voltage points (+_v, -_v) of the vehicle. Further, each contact is connected through impedance Z into the signal input point (s_v). If a contact (k₁) touches the positive group of elements, the positive supply voltage is switched through D₁ into +_v; if a contact touches the negative group of elements, the negative supply voltage is switched through D₂ into -_v; and if a contact touches the signal group of elements, both rectifiers (D₁ and D₂) would be reversely biased, because the signal as to d-c level would be between levels of supply voltages. The potential at the signal input point (s_v) would be a weighed mean value of potentials of different contacts. Thus the signal level would not remain constant in this kind of input circuit, but it would depend on how many contacts of a vehicle were touching in each group of elements. While this could be a disadvantage, e.g., in connection with amplitude modulation, this could be overcome by having the signal transmitted by the base unit (1) include a reference signal of constant amplitude. The vehicles would then be equipped with circuits for receiving a reference signal and signals corresponding to different functions of the vehicles and with circuits for comparing amplitudes of order signals with a reference signal. This kind of arrangement is not necessary if such modes of modulation are used which do not necessitate constancy of signal level, e.g., pulse duration or pulse frequency modulation. Because then the value of information is based on a time quantity and variation in signal level may be allowed. By using the input circuit of FIG. 2, the effect of disturbances of power devices on the signal side are not blocked but because by means of power elements are not transmitting signals, disturbances can be eliminated cheaply and effectively by coupling a sufficiently large capacitor over the power outputs of the base unit. When rapid disturbances between power outputs of the base unit are eliminated, it remains possible to have disturbances due to voltage variations over rectifiers D₁ and D₂. By using capacitors over supply voltage points (+_v, -_v) of the vehicles, these variations may be reduced. If necessary, separate supply voltage points should be formed for feeding power devices by using additional rectifiers connected to the contacts. In practice, it is sufficient to use additional rectifiers on either side of the two polarities depending on which polarity is used as a reference in coupling transmitting and receiving circuits. The solution may be analogous to that presented in FIG. 4 in connection of an input circuit of another kind.

The effect of supply voltages to the signal input point can be blocked by contacts connected to the signal point through gate circuits which permit only potentials being within certain direct voltage limit to have access to the signal point. When signals are kept between

supply voltages within certain limits, blocking of supply voltages is thus possible. FIG. 3 shows an example of an input circuit which is equipped with gate circuits. Each contact ($k_1, k_2, k_3, \dots$) is coupled to rectifiers ($D_1, D_2, \dots$) for steering incoming supply voltages to respective positive and negative supply voltage points ($+v, -v$) and a gate circuit, each gate consisting of transistor T, diodes D_c and D_d and resistances R_1, R_2 and R_3 . If a contact touches the group of elements of positive supply voltage, a high potential through diode D_c is placed on the collector point of corresponding transistor T, diode D_d becoming reversely biased in consequence of this. If a contact does not touch any group, the same result as above can be attained by proper evaluation of resistances R_1, R_2 and R_3 . If a contact touches the group of elements of negative supply voltage, a corresponding transistor T drives due to proper evaluation of resistances R_1 and R_2 thus causing potential of the corresponding collector point to become so high that corresponding diode D_d becomes again reversely biased as well as this time also diode D_c . On the contrary, when a contact touches the signal group of elements, diodes D_c and D_d are leading and then the potential of the signal point (s_v) follows the potential of corresponding collectors which in turn follow the potential of the signal group of elements. Leading diodes D_d are driving current through R_4 . With the aid of the input circuit of this kind it is possible to receive both a-c and d-c signals.

FIG. 4 presents another modification of the input circuit. As compared to the circuit of FIG. 3, the circuit of FIG. 4 is equipped with a separated, filtered supply voltage ($+s, -s$) for electronic circuitry of an object whereas circuits comprising power devices are supplied from points $+p, -p$. This avoids the effect of possible disturbances in the signal circuitry. Filtering is accomplished by means of resistance R_6 and capacitor C_1 . Of course, the supply voltage ($+s, -s$) could be also Zener diode stabilized. With the aid of diode D_4 and resistor R_7 , a bias is arranged for transistors T. In FIG. 4, a negative polarity of power supply for power devices has been formed by means of additional rectifiers D_3 to eliminate possible variations of potential over rectifiers D_2 caused by power devices. The circuit of FIG. 4 also includes a resistor R_5 so that the case when a contact is not touching any group can be taken into account by evaluation of resistances R_1, R_2 and R_5 so that corresponding transistor T becomes driving.

When a general m -group system is used and contacts of an object are arranged so that in every situation every group of elements is touched at least by one contact of an object, signals from every signal group appear in the contacts. When several signals with different d-c levels are applied to the signal point (s_v), the signal with the lowest d-c level will have access into it (in case of circuits presented in FIGS. 3 and 4) and the others are blocked. In this manner, the signal of that group to which an object belongs is steered to the signal point (s_v) by evaluating resistors R_1 and R_2 so that in case of signals with too low d-c levels, corresponding transistors T become driving and thereby access of said signals to the signal point (s_v) is blocked.

As mentioned above, the transfer of information can be based upon a frequency division or a time division principle or combinations of these. In connection with

a general m -group system, it is also possible to separate orders in a way that could be regarded as a space division principle from the point of view of the structures of the base unit and the surface, but from the point of view of circuits in the vehicles it could be regarded as a level division principle. In the simplest cases, a frequency division principle would be advantageous because then the transfer of information could be continuous, and the vehicles do not need memory circuits for storing information. FIGS. 5 and 6 present an example, in block diagram form, of a pure frequency division principle in connection with an input circuit according to FIG. 2. In this example it is assumed that every order associating with the device is transmitted with a frequency specific to the order. Different orders are summed and superimposed on a certain d-c level and fed into the surface, and a pulse duration modulation is used as the modulation method. FIG. 5 presents the circuits needed in the base unit. In it there would be an oscillator (2) for each order associated with the device. The output (s_B) of the output stage 6 feeds the signal group of elements of the surface. Access of signals from the oscillators to the output stage 6 is controlled by gates (3, etc.). The gate 3 is opened by a monostable multivibrator 4 for a period of time, the duration of which depends upon the momentary value of the order in question. The multivibrator is triggered into the unstable state by a pulse generator 5 functioning on a constant frequency so that the relative time of each gate being open depends upon the value of the corresponding order. The multivibrators corresponding to different orders may be triggered at the same time or the orders may be divided into two or more groups for effecting a more even temporal loading of a transmitting channel.

In the case of two groups, this can be accomplished by using a pulse generator producing a symmetrical rectangular wave and by using two derivative circuits for producing derivative impulses of opposite polarity for triggering the two groups of monostable multivibrators. FIG. 6 shows such a circuit in block diagram form. From signal point (s_v) of the vehicle the signal enters a tuned circuit (7). This is followed by a detector circuit (8), in which the signal is rectified and filtered for producing a d-c pulse, the duration of which depends upon the opening time of a corresponding multivibrator in the base unit. The mentioned d-c pulse is formed to a constant amplitude pulse in a pulse-forming circuit (9), which may be composed of a Schmitt-trigger circuit equipped with a bottoming output transistor to get a pulse height nearly as great as the supply voltage, which is advantageous from the point of view of power efficiency. With the aid of a filter circuit (10), the formed pulse train of constant amplitude may be converted into direct voltage, the value of which depends upon the value of the corresponding order. This direct voltage output (a) may control a corresponding power device in the vehicle. Alternatively it is possible to control corresponding power device from point (b) without filtering. In that case, filtering is effected in the power device itself, as in a motor. This alternative would be advantageous from the point of view that power efficiency would be best, because power losses in control means for the power device, as in a transistor, would remain small in all circumstances.

In a broad system it might be advantageous to use carrier waves specific to each vehicle. These carrier waves would be modulated with frequencies specific to each function. If the same frequencies are used for a certain function of all vehicles, it is possible to get along with a relative small number of oscillators. The vehicles would then be equipped with circuits for indicating and demodulating corresponding carrier waves and circuits for indicating and demodulating waves corresponding to different functions.

By using an input circuit equipped with gates as presented in FIGS. 3 and 4, all modes of information transfer are available. So it is possible to use a pure frequency division principle or a time division principle or combinations of these. The last mentioned case could be adapted, e.g., so that orders to different objects are transmitted in sequence and different orders of a certain object are transmitted simultaneously by means of specific frequencies. The objects could be informed about their sequence by means of some specific mark signal, which could be a certain d-c level specific to the object or an a-c signal or a combined signal with several characteristics. In the case of a time division principle, sequences of objects would be divided into subsequences corresponding to each order. In connection with a time division principle adapted with an input circuit according to FIGS. 3 and 4, the transmission of analog form information could be advantageously based on transfer with d-c levels. Then the objects could be equipped with delay circuits to open memories corresponding to different orders in sequence. The vehicles might be informed about their sequence by means of a specific mark signal, which could be a specific a-c signal, a d-c signal, which might be coded for sufficient specificity, or a combined signal, e.g., a combination of a specific frequency and a certain d-c level.

An example of a case wherein values of orders are sent in sequence by means of d-c levels, and a mark signal of specific frequency is used to inform vehicles about their sequence, is presented in FIGS. 7 and 8. FIG. 7 presents in a block diagram form, the circuits of the base unit. Into the output stage 11, the output of which (s_B) feeds the signal group of elements on the surface, enter mark signals specific to each vehicle through gate 12 and control orders from control units (13, 14 etc.) through gates (15, 16 etc.) specific to the vehicles and through gates (17 etc.) specific to functions. The circuitry includes two electronic selectors, namely a function selector 18 and a vehicle selector 19. These selectors may be, e.g., of a ring counter-type, and may have as many states as functions and vehicles involved in the system. The states of selectors would be determined from which control unit (13, 14, etc.) d-c orders have access to the output stage 11 as well as which mark signal from oscillators (20, 21, etc.) have access through gates (22, 23, etc.) into the gate 12. A pulse generator 24 triggers the function selector 18 to step to a state corresponding to the following function. When the whole cycle of functions is over, the function selector gives an output pulse, which triggers the vehicle selector 19 to step to a state corresponding to the following vehicle. A triggering pulse also triggers a delay circuit 25, which in turn causes monostable multivibrator 26 to open gate 12 at the beginning of a

sequence of each vehicle. The output stage 11 may be equipped with a circuit for smoothing transitions from one d-c level to another to avoid disturbing transients in turned circuits of objects.

FIG. 8 presents the required circuits of vehicles in block diagram form. According to FIG. 8, a mark signal in the signal point (s_V) enters a frequency indicator circuit 34 which is followed by a Schmitt-trigger 35, the output of which can trigger delay circuits (27, 28, etc.). The output of the Schmitt-trigger opens memory 29, the other memories (30, 31, etc.) being opened in sequence by corresponding monostable multivibrators (32, 33, etc.). When memories are opened in sequence, the corresponding d-c level from input point (s_V) is read into them.

If a mark signal is used which is a combination of a certain frequency and a certain d-c level, these d-c levels might be selected to the outside the limits of the level used for transmitting analog information. Thus at the same time an alternative way can be achieved for avoiding the effect of transients associated with rapid shifting of d-c levels in information transfer. Transients could, of course, be eliminated also by proper design of indicator circuit 34 on the basis of short duration of transients compared with mark signals. Different functions of objects would apparently in all practical adaptations remain so small that realization of individual delay circuits, which may be monostable multivibrators, would be possible with tolerances of normal commercial components. In most practical cases, the number of functions might be two to four. Some orders may further be such that requirements for transfer are quite low, for example, information may be a simple on-off order. In such cases, simplification of the principle presented in FIGS. 7 and 8 is possible. Two orders can be transmitted with the aid of d-c levels without delay circuits so that orders are transmitted in sequence and the mark signal specific to the vehicle is transmitted so that it starts during the former sequence and ends during the latter sequence. The start and the end of the mark signal can be used with the aid of derivative circuits for opening memories corresponding to d-c orders. Two additional orders can be transmitted with the aid of amplitudes of mark signals and durations of those signals.

FIG. 9 presents in block diagram form, circuits of objects when two analog form orders and one on-off order are transmitted. In these circuits, a mark signal is received, detected and formed by indicator 34' and trigger 35' circuits. Derivative circuits 36 and 37 open memories 38 and 39 at the start and at the end of the mark signal. Additional Schmitt-trigger circuit 40 is designed to react when the amplitude of the mark signal exceeds a certain level when on-off information is received. It is clear that with the aid of amplitude, analog information might also be transmitted quite reliably. In the case of FIG. 9, corresponding circuits in the base unit should be modified as in FIG. 7, so that the function selector 18 might be reduced to a flip-flop circuit and the control of the third order could be achieved by controlling outgoing amplitude of oscillators (20, 21, etc.).

In connection with a m-group system, the base unit should be supplied with $m-2$ separate signal outputs, each connected to corresponding groups of elements of

the surface. In spite of separate output stages of these $m-2$ transmission channels, several circuits common to all channels might be used. So, in the case of FIG. 7, control units (13, 14, etc.), gates (15, 16, etc.) and (17, etc.), as well as output stage 11, have to be individual to each channel whereas other blocks may be in common.

What is claimed is:

1. A system for the transmission of remote control information and power to remote-controllable objects moving on a surface, comprising a surface which is equipped with a plurality of groups of conducting material elements, two of said groups being fed by direct current supply voltage and a third group by a remote control signal formed by a remote control unit, which as for its d-c level remains between the levels of the supply voltage, the objects moving on the surface being equipped with contacts for transmitting the supply voltage and the remote control signal to the objects, the objects being equipped with an input circuit, which consists of rectifier elements for steering incoming supply voltages to corresponding supply voltage points of the circuits of the object and blocking access of remote control signals to these points, and circuits for steering the remote control signals to a signal input point of receiving electronic circuits.

2. A system in accordance with claim 1 wherein each contact of an object is coupled to the signal input point of the object by means of an impedance, a potential in the signal input point being thus a weighed mean value of potentials of different contacts.

3. A system in accordance with claim 1 wherein each contact of an object is coupled to the signal input point of the object by means of a gate circuit which permits only potentials which as for their d-c level are within certain limits corresponding to levels of a signal allowed to have access to the signal point and thus blocking the effect of supply voltages to said point.

4. A system for the transmission of remote control information and power to remote-controllable objects moving on a surface, comprising a surface which is equipped with m groups of elements of conductive material, of which two groups are fed by direct current supply voltage and $m-2$ groups by remote control signals formed by a remote control unit, signals of each group being always as for their d-c level within certain nonoverlapping limits, levels of all groups being between the levels of the supply voltages, the objects moving on the surface being equipped with contacts for transmission of the supply voltage and the remote control signals to the objects, the object being equipped with input circuit which consist of rectifier elements for steering incoming supply voltages to corresponding supply voltage points of the circuits of the object and blocking access of the remote control signals to these points, and gate circuits between said contacts and a signal input point of receiving circuits, said gates permitting only signals which as for d-c level are within certain limits corresponding to a certain signal group of elements of the surface to have access to the signal input point.

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