

March 6, 1934.

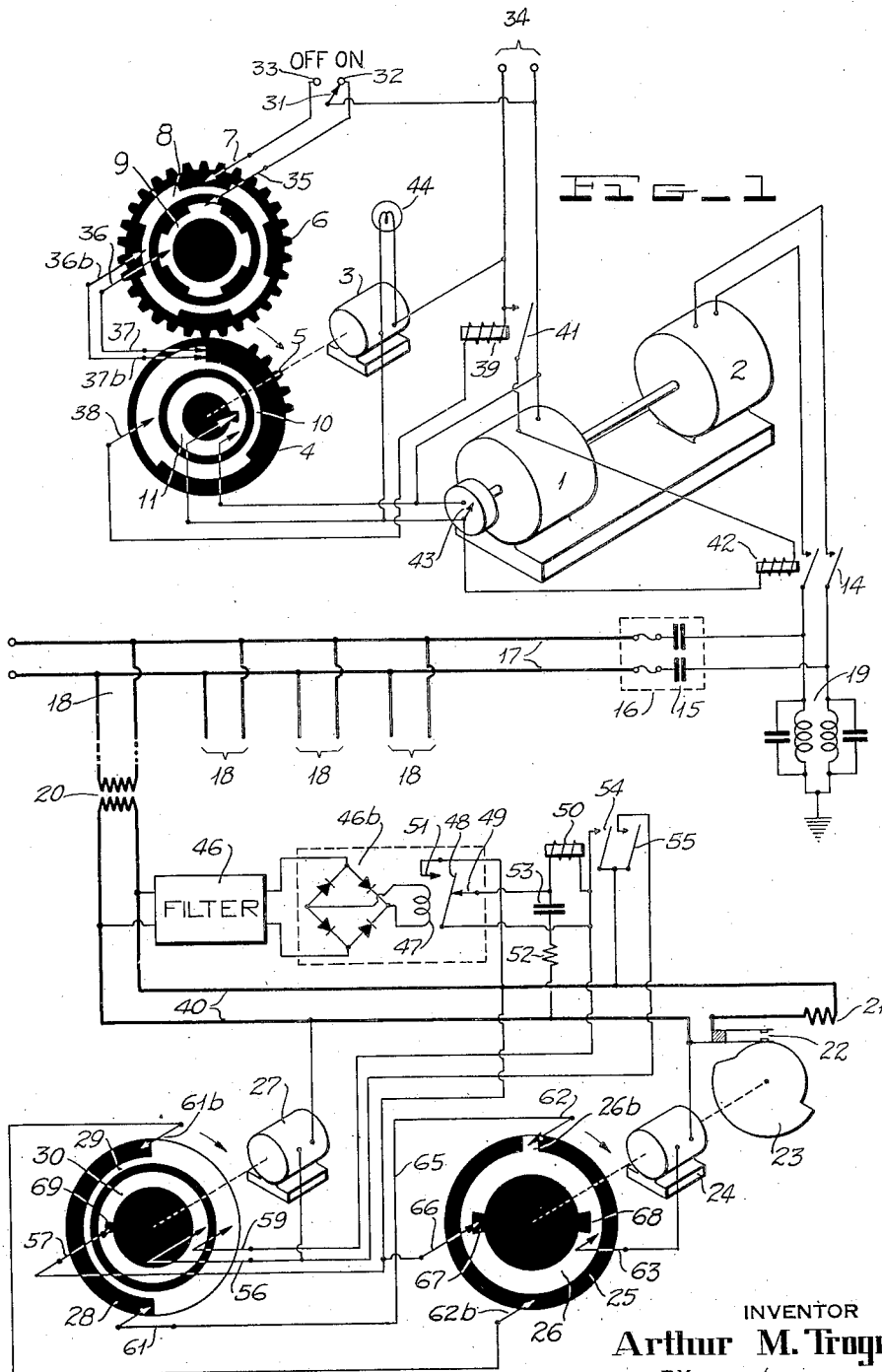
A. M. TROGNER

1,949,590

CONTROL SYSTEM

Filed July 27, 1932

2 Sheets-Sheet 1



INVENTOR
Arthur M. Trogner
BY
Wm. J. Herdman
ATTORNEY

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2 Sheets-Sheet 2

FIG. 2

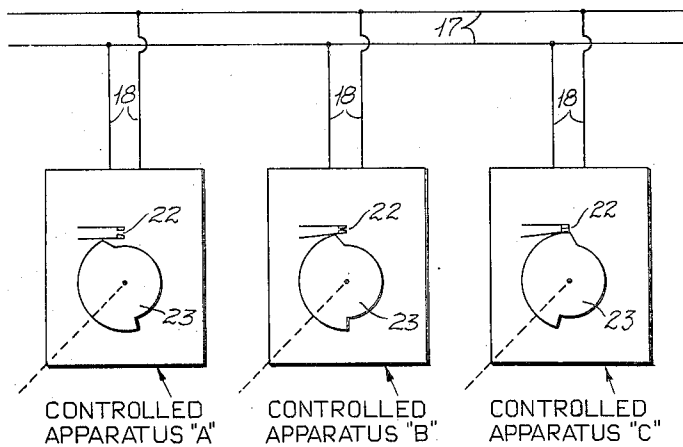
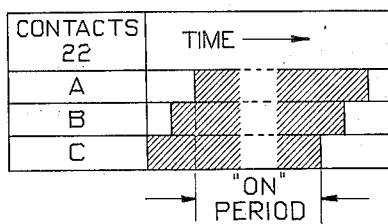


FIG. 3



INVENTOR

Arthur M. Trogner

BY *J. Herdman*
ATTORNEY

UNITED STATES PATENT OFFICE

1,949,590

CONTROL SYSTEM

Arthur M. Trogner, Maplewood, N. J., assignor to
Wired Radio, Inc., New York, N. Y., a corporation of Delaware

Application July 27, 1932, Serial No. 625,177

5 Claims. (Cl. 171-97)

My invention pertains in general to control systems and specifically relates to carrier current systems for remotely controlling power switching operations.

In commercial power distribution, the consumers' power consumption during certain periods of time is high, while, at other times, the consumers' power consumption is relatively low. That is, the power demand curve for central station generating apparatus shows decided peaks at certain hours of the day. For example, at that period of the day during which darkness begins, the power demand curve rises sharply and decreases towards the later hours of the evening. Such conditions make it necessary to provide sufficient generating apparatus to supply the limited period of maximum demand. Such generating apparatus will not be operating at maximum efficiency during the other periods in which the power demand is considerably less. It will be obvious that it is very desirable to direct efforts towards equalizing the power consumption loads whereby the power generating apparatus can be operated at more nearly the same level during the entire day. It is, therefore, to the advantage of the power distribution company to offer certain inducements to the consumer for using power during those periods of the day when the demand is generally low.

My invention contemplates providing a system to enable a power company to remotely control certain of the consumers' loads, such as water heaters and the like, whereby the rate of power consumption by such loads may be materially reduced. That is, in view of the fact that the consumer agrees to operate certain of his loads during restricted times of the day he is given a reduced rate. The system of my invention provides means whereby a load dispatcher at a central point of a power distribution network can effectively control all of such "special" or "restricted" loads at various outlying points and in a manner such that will be positive, efficient, and economical.

One of the objects of my invention consists in providing a control system for effecting the operation of power switches at a remote point by means of carrier frequency energy transmitted over power lines.

A further object comprises providing a system including a power distribution network for supplying commercial power to a consumer's load in which means are provided for controlling the power consumption of the consumer's load from a central point.

A still further object consists in producing a power distribution network control system including a plurality of carrier current operated switches situated at various remote points and provided with means for keeping in step with each other under control of a common control unit.

I accomplish these and other desirable objects in a power distribution system comprising means for transmitting carrier current timing impulses over power lines for controlling power switching apparatus at a remote point.

In the drawings which represent a preferred form of my invention:

Fig. 1 is a diagrammatic representation of my control system;

Fig. 2 is a schematic representation of a timing operation in my system; and

Fig. 3 is a graphic representation of the feature of Fig. 2.

Referring to the drawings in detail, there is provided a motor-generator set including an alternating current motor 1 for driving an alternator 2 designed to produce carrier current of a desired frequency when the motor 1 is running at normal speed. A motor 3 is provided for driving a disc 4 composed of insulating material such as fiber or a phenol condensation product. The motor 3 is preferably of the self-starting synchronous type adapted to keep in step with a commercial alternating current supply, although the motor 3 may be of other types if desired.

The disc 4 is provided with several peripheral teeth 5 and is arranged for rotation in juxtaposition with a rotatable disc 6 having teeth around the entire periphery thereof whereby each complete revolution of the disc 4 causes an angular movement of the disc 6 which is only part of a complete revolution. The disc 6 is composed of insulating material similar to the disc 4 and is provided with two concentric contacting rings 8 and 9 of a special construction which will be more apparent later. The disc 4 is provided with concentric contacting rings 10 and 11 also of a special construction which will be more apparent later.

Carrier current from the alternator 2 is supplied through a contactor 14 to condensers 15 which are coupled through fuses 16 to power busses 17. Power busses 17 are connected with a suitable source of commercial power and are provided with outgoing distribution feeder lines 18. The power busses 17 and feeder lines 18 are indicative, in general, of a commercial power dis-

tribution system for serving a plurality of out-
lying consumers. For purposes of description
one of the feeder lines 18 will be considered in
connection with a consumer's load and control
apparatus associated therewith in accordance
with my invention, although it will be under-
stood that, in practice, a great many different
consumer's loads and associated control appar-
atus are connected with the power distribution
network through the various feeder lines.

Drain coils 19 are connected between coupling
condensers 15 and ground as shown. The feeder
lines 18 under consideration are connected to the
primary of the consumer's step-down transform-
er 20, the secondary of which has connections to
the consumer's load indicated by a resistance 21.
The power circuit to the consumer's load 21 is
controlled by a suitable form of contactor 22,
operated by a cam 23 of a construction more ap-
parent later. The cam 23 is rotated by a motor
24 preferably of the self-starting synchronous
type. It will be understood, of course, that the
motor 24 may be of other types, if preferred,
the only consideration being that the controlling
elements moved thereby are maintained in syn-
chronism with the corresponding controlling ele-
ments associated with the carrier current trans-
mitting apparatus. The motor 24 is mechanically
coupled with an insulating disc 25 having a con-
tacting ring 26 thereon. Another motor 27 sim-
ilar to the motor 24 is provided for rotating an
insulating disc 28 having contacting rings 29 and
30 thereon. The contacting rings 26, 29, and 30
are all of special construction described later.

Further details of the construction of the ap-
paratus shown in the drawings will be understood
in connection with its operation from the fol-
lowing. A switch 31 which, in association with
the motor generator 1—2 and motor controlled
discs 4 and 6 may be located at a sub-station or
other convenient point of a power distribution
system, is provided for selective engagement with
either of two contacts 32 or 33 corresponding to
"on" and "off" positions. This switch 31 is for
use of an operator, such as a "load dispatcher", for
controlling various consumers' loads in accord-
ance with the principles of my system. When it
is desired that all of the various consumers' loads
shall be in an operative condition for consump-
tion of power, the switch 31 is moved into en-
gagement with contact 32 in the "on" position
as shown in the drawings. A connection is then
established from one of the terminals 34, which
are connected to a source of operating current,
through contact 32 to a brush 35 engaging with
the contacting ring 9. A circuit is continued
from contacting ring 9 through a brush 36 to
another brush 37 engaging with the contactor
ring 10. From contacting ring 10 the circuit is
completed through brush 38 to an electromagnet
39 and thence back to the other of the terminals
34 whereby operating energy is supplied to the
electromagnet 39.

The electromagnet 39 upon being energized at-
tracts an armature 41 which completes a circuit
from the terminals 34 to the motor 1. The motor
1 is thereby energized and drives the alternator
2. When the armature 41 is closed a circuit is
established from one of the terminals 34 through
an electromagnet 42 to a switch 43. The switch
43 is of the type designed to operate in associa-
tion with the armature shaft of motor 1 whereby
a circuit is established therethrough only when
the armature shaft of the motor 1 is running at
a predetermined speed, which, in the present in-

stance, is the normal speed of rotation for caus-
ing the alternator 2 to supply carrier current of
the desired frequency. When the motor 1 comes
up to normal speed the switch 43 is closed thereby
establishing a circuit from the terminals 34 to
motor 3. Energization of motor 3 causes a signal
lamp 44 to be illuminated and causes the disc 4
to be rotated in a clockwise direction indicated
by the arrow. At the same time, closing of switch
43 causes the energization of magnet 42 whereby
the contactors 14 are closed. The closing of con-
tactors 14 causes carrier current of a desired fre-
quency to be impressed upon the power busses 17
and associated feeder lines 18. The contacting
ring 10 on disc 4 is so formed that after the disc
4 has rotated approximately 135° of arc, the con-
tacting ring 10 will be disengaged from the brush
37 as will be apparent from the figure. The fact
that the brush 37 is disengaged from the contact-
ing ring 10 at 135° of revolution is arbitrary in-
asmuch as the purpose of rotation of the brush
and contacting ring is for timing purposes and it
will be understood that a certain latitude in the
timing of carrier signals in accordance with my
system is permissible, the principal consideration
being that two signals of different timing char-
acteristics be transmitted.

Disengagement of brush 37 and contacting ring
10 interrupts the circuit to electromagnet 39
whereby electromagnet 39 is deenergized, thereby
releasing armature 41 and immediately causing
the interruption of the energizing circuit to elec-
tromagnet 42. When the electromagnet 42 is de-
energized the armatures 14 are released thereby
interrupting the carrier current transmission cir-
cuit so that the carrier current signal on the
busses 17 is terminated. When the electromag-
net 39 is deenergized the circuit to motor 1 is in-
terrupted, thereby shutting down the motor gen-
erator 1—2. When the armature 41 is released,
the circuit to motor 3 through electromagnet 42
and switch 43 is interrupted. However, operat-
ing energy is supplied to the motor 3 by a circuit
completed from the terminals 34 through a pair
of brushes which engage with contacting ring
11. The contacting ring 11 is provided with an
insulating notch which corresponds to the initial
or starting position of the disc 4. It will be evi-
dent, therefore, that operating energy to the mo-
tor 3 will be supplied by a circuit through the
brushes contacting with ring 11 until the disc 4
is rotated into its initial position whereby the in-
sulating notch of ring 11 will engage one of the
brushes thereby interrupting the circuit to the mo-
tor 3 which will accordingly be deenergized and
the disc 4 brought to rest. It will be seen, then,
that the purpose of contacting ring 11 and the
associated brushes is for maintaining energiza-
tion of motor 3, during the period when the ar-
mature 41 is released, whereby the disc 4 is re-
turned to its initial or starting position. As the
disc 4 is brought into its starting position at the
completion of a revolution, the teeth 5 will engage
with the teeth of the disc 6 to impart an angular
movement thereto which will be sufficient to cause
the contacting rings 8 and 9, because of their con-
struction of alternate extending portions, to dis-
engage from the brush 35 and to engage with
brush 7, respectively, thereby interrupting the cir-
cuit from contact 32 and preparing a circuit from
contact 33.

It will now be seen that a carrier current im-
pulse of a predetermined duration has been trans-
mitted over the power busses 17 and associated
feeder lines 18. This impulse is fed through a

filter 46 which is of the band-pass type designed to accept only those frequencies within the desired carrier frequency range. The output of filter 46 is directed to a rectifier, which, in the present embodiment of my invention, is preferably of the four-element copper oxide full-wave type having connections across its conjugate points to a galvanometer energizing coil 47 which attracts an armature 48. Before energization of coil 47, the armature 48 is in engagement with a contact 49 which short-circuits an electromagnet 50. When the coil 47 is energized the armature 48 leaves contact 49 and engages with contact 51 thereby establishing a circuit from the secondary power circuit 40 through a resistor 52 and condenser 53 to the electromagnet 50. The resistor 52 and condenser 53 are provided for the purpose of supplying a reduced voltage to the electromagnet 50. Energization of electromagnet 50 attracts a contactor comprising armatures 54 and 55. Closing of armature 55 establishes a circuit to a brush 56 engaging with the contacting ring 30 while the closing of armature 54 establishes a circuit to a brush 59 engaging with contacting ring 29. Closing of contact 54 completes a circuit from the power circuit 40 to the electromagnet 50 which may be terminated only by engagement of armature 48 with contact 49 thereby short-circuiting electromagnet 50.

When the armature 55 is closed, operating energy is supplied from the power circuit 40 to the motor 27 thereby beginning the rotation of disc 28. Rotation of disc 28 causes contacting ring 29 to engage with a brush 61 connected with brush 62 in engagement with a portion of contacting ring 26 of disc 25. A circuit is then established through brush 63, also in engagement with ring 26, to motor 24 whereby the rotation of disc 25 and cam 23 is begun.

The motors 24 and 27 rotate substantially in synchronism with the motor 3. When the disc 4 is rotated by motor 3 into a position such that the contacting ring 10 is brought out of engagement with brush 37, the contactor 14 is opened thereby terminating the carrier current signal for the "on" position of switch 37 as before described. Termination of the carrier current signal over lines 18 will cause the deenergization of coil 47 whereby armature 48 will disengage contact 51 and will engage contact 49, thereby short-circuiting electromagnet 50. It will be evident that the armature 48 does not directly interrupt a power circuit since operating energy is now being supplied to the electromagnet 50 through contactor 54.

When the electromagnet 50 is deenergized the contactor 54—55 is released and the circuits there-through are opened. The circuit from brush 59 through contacting disc 29 and brush 61 will be now interrupted at brush 62 inasmuch as the disc 25 has rotated the projecting portion 26b of contacting ring 26 out of engagement with the brush 62. However, power will be supplied from the circuit 40 by a connection 65 through brush 66 to motor 24 and also through brush 57 and brush 56 to motor 27. The ring 26 is provided with two internal insulating notches 67 and 68. Following the course of operations now under consideration, when the notch 68 comes into engagement with the brush 66 the circuit to motor 24 will be interrupted whereby the cam 23 will be brought to rest in a position such that the contactor 22 is closed, thereby completing the power circuit to the consumer's load 21. The disc 25, then, has completed half of a revolution and has been

brought to rest. The rotation of disc 28 continues to one complete revolution whereupon an insulating notch 69 in ring 30 is brought into engagement with brush 57, thereby interrupting the circuit to motor 27 and bringing the disc 28 to rest.

It will now be assumed that the operator or load dispatcher desires to interrupt the power circuit to the consumer's load 21. The load dispatcher will then throw switch 31 to "off" position in engagement with contact 33.

One of the extending portions of contacting ring 8 is now in engagement with brush 7 whereby a circuit is completed through brush 36b to brush 37b in engagement with contacting ring 10. A circuit will be completed from brush 38 to electromagnet 39, as before, whereupon operation of motor generators 1—2 is initiated. When the motor 1 comes up to normal speed the controlling switch 43 is closed thereby completing the circuit to electromagnet 42 and to motor 3. Motor 3 rotates disc 4 while the alternator 2 transmits a carrier signal of the proper frequency through contactors 14 which are now closed. The carrier current signal being transmitted will be terminated when the portion of ring 10, with which brush 37b engages, is rotated out of engagement therewith. It will be noted that the portion of ring 10 which engages with brush 37b is, in the present instance, of 270° of arc as compared with the portion of ring 10 which engages with brush 37, which is only 135° of arc. As before explained, this construction will permit the "off" signal through brush 37b to be of approximately twice the duration of the "on" signal through brush 37. As before stated, it will be understood that considerable latitude is permissible in this timing arrangement.

When the contacting ring 10 is rotated out of engagement with brush 37b the circuit to electromagnet 39 is interrupted, thereby also deenergizing electromagnet 42 and interrupting the carrier current signaling circuit. The power circuit to motor 3 will be maintained, as before, by ring 11 until the disc 4 is rotated a complete revolution into its initial position whereupon the insulating notch in ring 11 will interrupt the circuit to motor 3. At the same time the teeth 5 will engage the teeth of disc 6 to bring the extending portions of contacting rings 8 and 9 out of engagement with brush 7 and into engagement with brush 35, respectively, thereby establishing properly prepared circuits for the next movement of switch 31 by the load dispatcher.

The "off" signal is received by filter 46 and acting through rectifier 46b energizes the coil 47 to attract armature 48. Armature 48 leaves contact 49 and engages with contact 51 thereby energizing electromagnet 50. Energization of electromagnet 50 attracts armatures 54 and 55 whereupon a "holding" circuit is established for the electromagnet 50, as explained in connection with the reception of the "on" signal. Armature 54 further completes a circuit to motor 27 which initiates the rotation of disc 28 whereupon the extending portion of ring 29, after 180° of rotation of disc 28 is brought into engagement with the brush 61b for completing a circuit to a brush 62b. The extending portion 26b of ring 26 is now in engagement with brush 62b whereby a circuit is completed through brush 63 to motor 24. Energization of motor 24 causes the rotation of disc 25 which angularly moves cam 23 into a position in which the controlled switch contacts 22 are opened thereby breaking the

power circuit to the consumer's load 21. As the disc 25 is rotated the energizing circuit to motor 24 is maintained from connection 65 through brush 66. When the notch 67 comes into engagement with brush 66, after a half revolution of disc 25, this circuit will be interrupted thereby shutting down the motor 24 and bringing cam 23 to rest in the "off" position with respect to the controlled switch contacts 22. The disc 28, as before, will complete a revolution at which time the insulating notch 69 will come into engagement with the brush 57 and stop the motor 27 at the initial or starting position of disc 28. The entire apparatus of the sending and receiving equipment will now be in condition for a repeat operation.

One of the features of my carrier current control system resides in that the controlled apparatus is self-correcting should the controlled apparatus get out of step with the controlling apparatus. For example, it will be assumed that the disc 25 and motor 24 have, in some manner, gotten out of step with the controlling apparatus, and the cam 23 is in an "off" position in spite of the fact that the load dispatcher is about to send an "off" signal by switch 31. In this position of cam 23 the contacts 22 will be open and the extending portion 26b of contacting ring 26 will be in engagement with brush 62. The "off" signal will initiate the operation of motor 27 and disc 28 which will cause the energization of motor 24 thereby starting the disc 25 to rotate. When the disc 23 arrives at the "on" position closing contacts 22, the insulating notch 68 will engage with brush 66 thereby interrupting the circuit from connection 65 to motor 24. At this time, however, the "off" signal, being substantially twice as long as the "on" signal, will have maintained the energization of electromagnet 50 whereby armature 55 is still closed. Armature 55, being closed, completes a circuit through ring 30 during the time when insulating notch 68 is adjacent brush 66 whereby the energizing circuit to motor 24 is maintained. At the end of a complete revolution of disc 28, the insulating notch 69 will come into engagement with the brush 57 and at the same time insulating notch 67 will come into engagement with brush 66 whereupon the energizing circuits to motors 24 and 27 are interrupted. It will be seen then, that the cam 23 will still be in an "off" position and the contacts 22 will remain open, the disc 26 and cam 23 now being in step with the proper operation of the controlling apparatus. It is evident that the same correcting operation may apply to the "on" signal since the disc 25, whenever out of step, will always bring itself in step when the next controlling signal, either "off" or "on", is transmitted over the lines 18.

For example, it will be assumed that the cam 23 is in an "on" position in spite of the fact that the load dispatcher is about to send an "on" signal by switch 31. In this position of cam 23 the contacts 22 will be closed and the extending portion 26b of contacting ring 26 will be in engagement with brush 62b. The "on" signal will initiate the operation of motor 27 and disc 28. When the disc 28 starts to rotate the extending portion of ring 29 will come into engagement with the brush 61 which is connected with brush 62. However, the extending portion 26b of ring 26 is not now in engagement with brush 62 and the circuit at this point will be interrupted. The brush 66 will now be in engagement with the insulating notch 68 and consequently, there will be no energy

supplied to the motor 24. The cam 23 will therefore remain stationary and the contacts 22 will be maintained in a closed or "on" position. Before the extending portion of ring 29 has passed out of engagement with brush 61, the "on" carrier frequency signal will be terminated due to opening of switch 14. Consequently, the coil 47 will be deenergized which will bring about the release of armature 48, 54, and 55 so that there will be no energy supplied to the brush 61b when the extending portion of ring 29 comes into engagement therewith.

It will be evident then, that the motor 24 will still be unenergized. The disc 28 will be rotated a complete revolution as before whereupon the circuit to motor 27 will be opened and the disc 28 brought to rest at its initial position. Throughout the entire operation the motor 24 will be unenergized and the cam 23 and contacts 22 will remain in the "on" position. It will be evident, then, from this last described procedure that, in the event that the cam 23 should get out of step with the controlling signals to the extent that the cam is in an "on" position when an "on" signal is transmitted, the control system will be entirely automatic in self-correction so that the controlled apparatus is properly functioning "in step" with the signal transmitted in accordance with the position of switch 31.

It will now be apparent that the entire controlled apparatus of my carrier current control system is automatically self-correcting in the event that the controlled apparatus should accidentally get out of step with the controlling apparatus. If the controlled apparatus is out of step, the next controlling signal from the controlling apparatus, no matter whether it is an "off" or "on" signal, will serve to produce the proper correcting function so that the apparatus will again be in proper step for the ensuing controlling signal.

Another feature of my invention resides in that the cam 23 in each of the controlled apparatus units which may be connected to the various feeder lines 18 is angularly adjustable with respect to the shaft of the motor 24. In accordance with my invention, the cams 23 of the various groups of such controlled units are adjusted so that their respective contactors 22 will be operated at different times within a certain limit. That is, when the load dispatcher sends an "off" signal, the contactors in a certain group of controlled units will be opened at one instant, those of another group a few seconds later, and those in another group a few seconds still later. This feature prevents the sudden disconnection or connection, at one instant, of very large power loads. The addition or subtraction of the aggregate load of all of the various "restricted" loads may then be considered as taking place gradually within a restricted time limit, which, in the present embodiment of my invention, constitutes one-half revolution of the disc 25. The mechanical adjustment of the cam 23 with respect to the shaft of motor 24 can be accomplished in various ways, among which may be mentioned the use of a pin or key in one of the movable members which is inserted in any one of a number of differently angularly spaced holes in the other movable member so that the contactors 22 operate at any particular point of rotation of the cam 23 by the motor 24. This feature of applicant's invention is shown in Figs. 2 and 3 of the drawings. Fig. 2 shows the cams 23 angularly disposed in relation to the contacts

22 in three different sets of controlled apparatus, "A", "B", and "C", which may be connected to the different feeder lines 18. It may be seen, in Fig. 2, that each of the cams 23 is slightly angularly displaced with reference to the other cams 23. Such an arrangement results in a staggered relationship of the "on" and "off" switching operations as shown in the table of Fig. 3.

It will now be apparent that I have provided a control system which offers many advantages in its use, particularly in connection with the remote control of power consumption loads. By the use of my system a power distribution organization is enabled to supply power to consumers' "special" or "restricted" loads at reduced rates inasmuch as the distribution organization permits of absolute control over these loads from a central point. Although I have shown a preferred embodiment of my control system it will of course be evident that various modifications can be made therein without departing from the intended scope of my invention. I do not therefore desire to limit myself to the foregoing except insofar as may be pointed out in the appended claims.

What I claim as new and original and desire to secure by Letters Patent of the United States is:

1. In a system for remotely controlling consumers' power loads connected with a power distribution network, common controlling means for impressing on said network carrier current signals of predetermined but different durations, and a plurality of controlled means remotely situated from said first mentioned means but in the vicinity of the consumers' loads and each comprising, a filter coupled to said network and responsive to said signals, an electro-magnetically operated switch controlled through said filter, and rotating means for operating said switch controlling a consumer's load, said rotating means being adapted to have the movement thereof initiated by said electro-magnetically controlled switch and including contacting apparatus for causing the termination of movement of said rotating means in predetermined positions, said plurality of controlled means having their respective rotating means angularly displaced from each other in point of operation to produce a sequence of load controlling operations from the carrier signals impressed on said network by said common controlling means.

2. A control system in accordance with claim 1 in which each of said rotating means includes a plurality of rotatable insulating members carrying contacts, and motors for driving each of said rotatable insulating members, brushes for engaging with said contacts on said insulating rotatable members and in which said contacting apparatus includes brushes for engaging with

said contacts on said rotatable members, and connection between said brushes, said electromagnetically operated switches, and said network.

3. A control system in accordance with claim 1 in which each of said controlling means comprises, a pair of rotatable members having contacts thereon, brushes for engaging with said contacts, a motor for driving one of said rotatable members, said driven rotatable member being adapted to impart intermittent rotary motion to said other of said rotatable members, a motor and alternator driven thereby for supplying carrier frequency energy to said network, a manually controlled switch for connecting a source of power to certain of the brushes engaging with contacts on said driven rotatable member, and connections between the remainder of said brushes, and said motors, whereby the duration of rotation of said alternator is determined by the rotation of said rotatable member driven by said motor, the operation of said motor for driving said rotatable member being initiated by said manually controlled switch but terminated by the movement of said rotatable members.

4. A control system comprising controlling apparatus for producing differently characterized controlling signals, and controlled apparatus operated under the influence of said signals for performing different functions in accordance with the characteristics of said signals, said controlled apparatus comprising, circuit controlling means operable for assuming different predetermined positions according to the different predetermined characteristics of said signals and means operable, at the reception of signals, when said circuit controlling means has assumed other than the predetermined positions normally assumed due to the different predetermined characteristics of said signals, whereby said circuit controlling means is automatically brought into adjustment in a proper predetermined position in accordance with the predetermined characteristics of said last mentioned signal and the characteristics of ensuing signals.

5. In a system for remotely controlling a plurality of consumer's power loads connected with a power distribution network, controlling means for impressing on said network carrier current signals of predetermined characteristics, and a plurality of power load controlling devices for operation under the influence of said carrier signals, said controlled means being timed for operation whereby a commonly and simultaneously received signal produces the sequential or non-simultaneous control of the consumer's loads.

ARTHUR M. TROGNER.