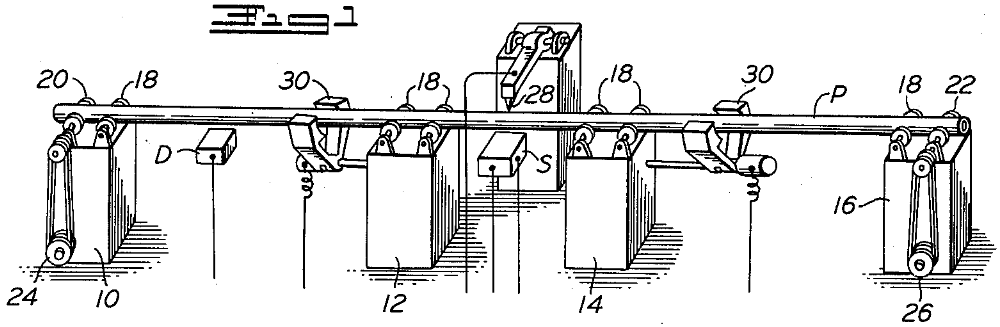
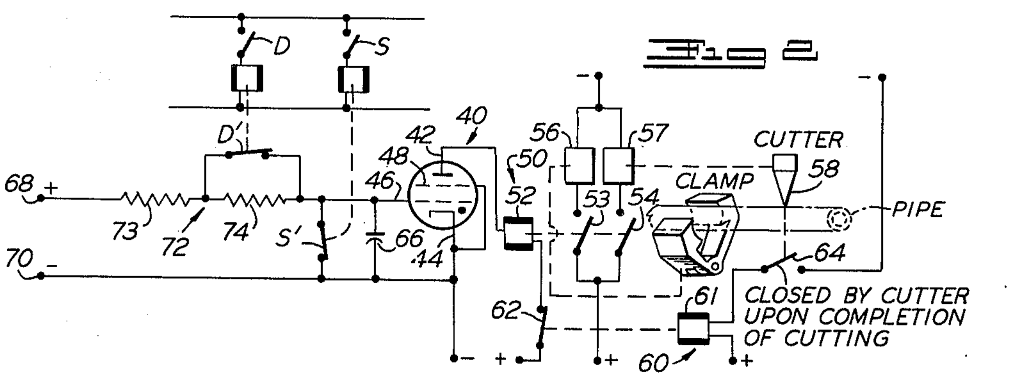
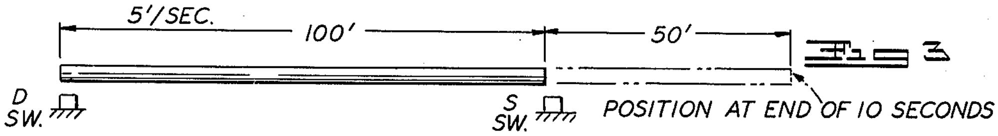
Oct. 12, 1965 C. D. BENNETT 3,211,036

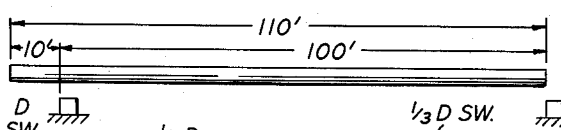
ELECTRONIC TIMING AND CUTTING APPARATUS

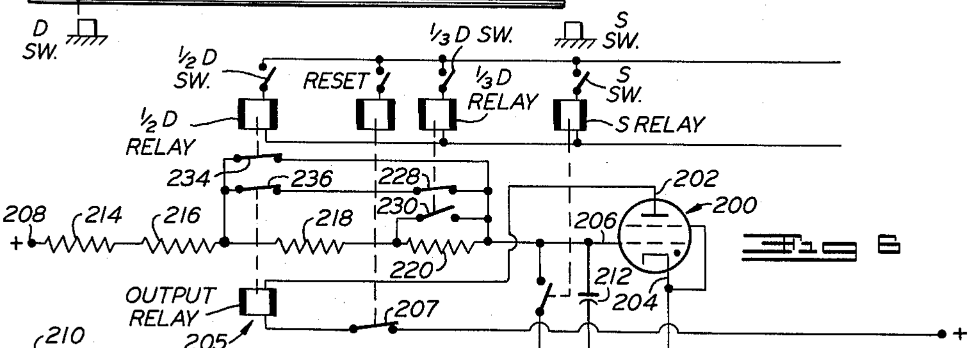
Filed Nov. 5, 1962 5 Sheets-Sheet 1

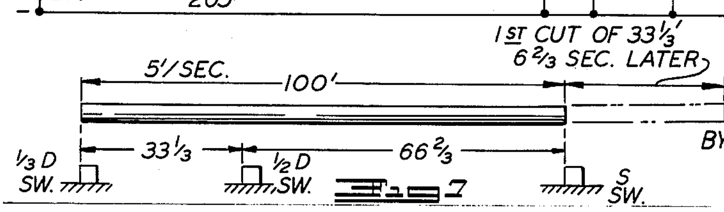












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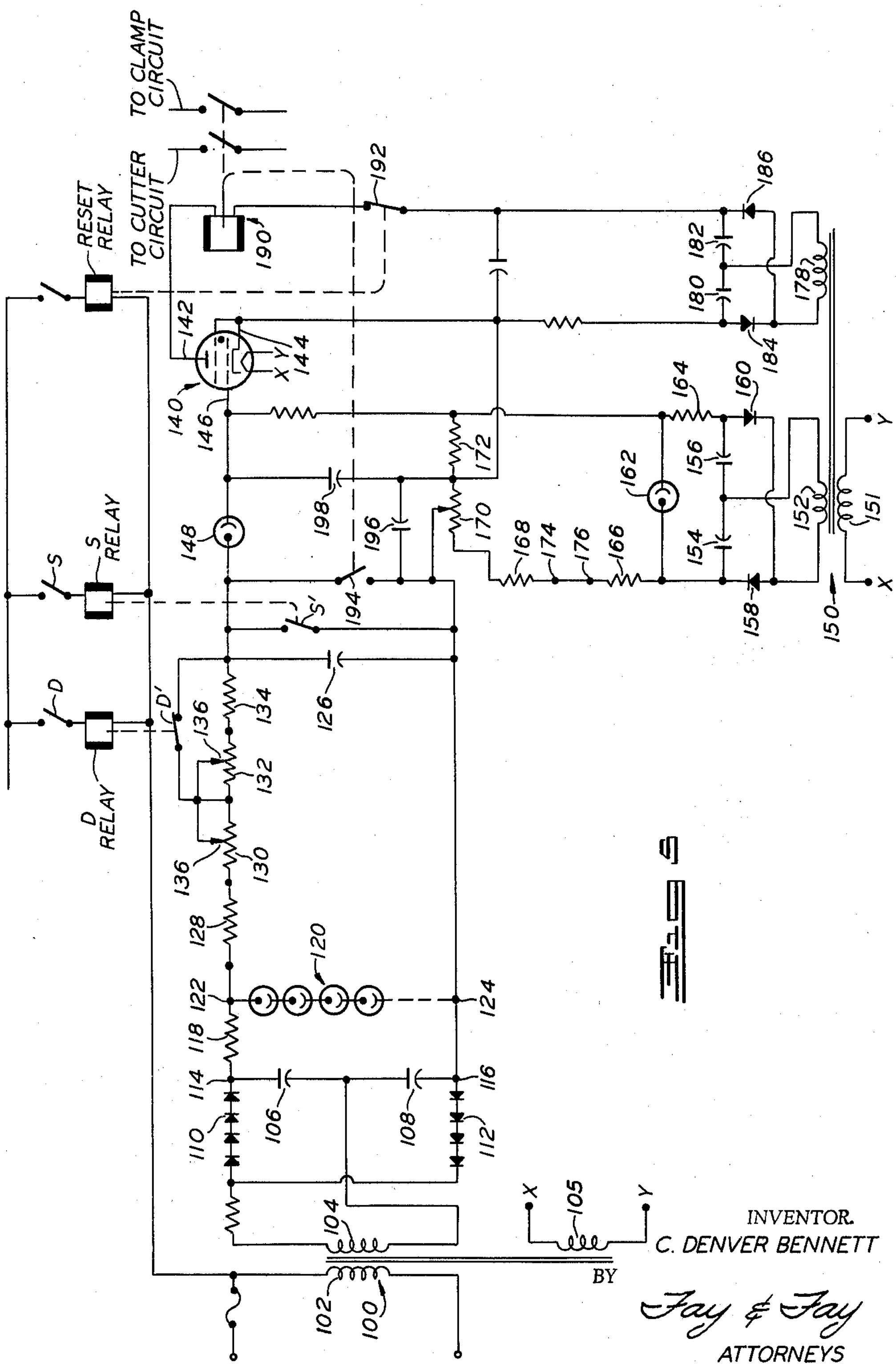

FIG. 5

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Oct. 12, 1965 C. D. BENNETT 3,211,036

ELECTRONIC TIMING AND CUTTING APPARATUS

Filed Nov. 5, 1962 5 Sheets-Sheet 3

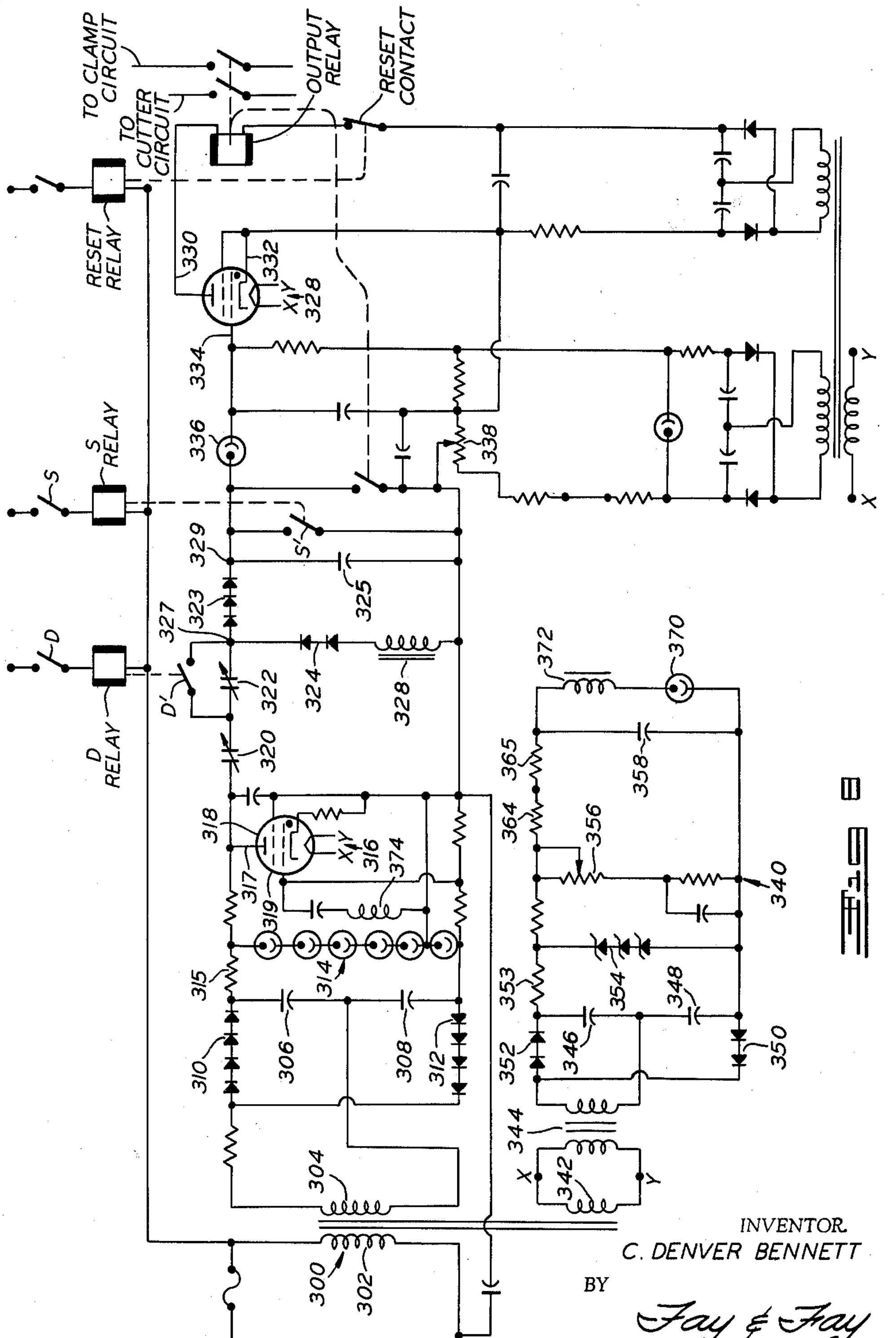

FIG. 3

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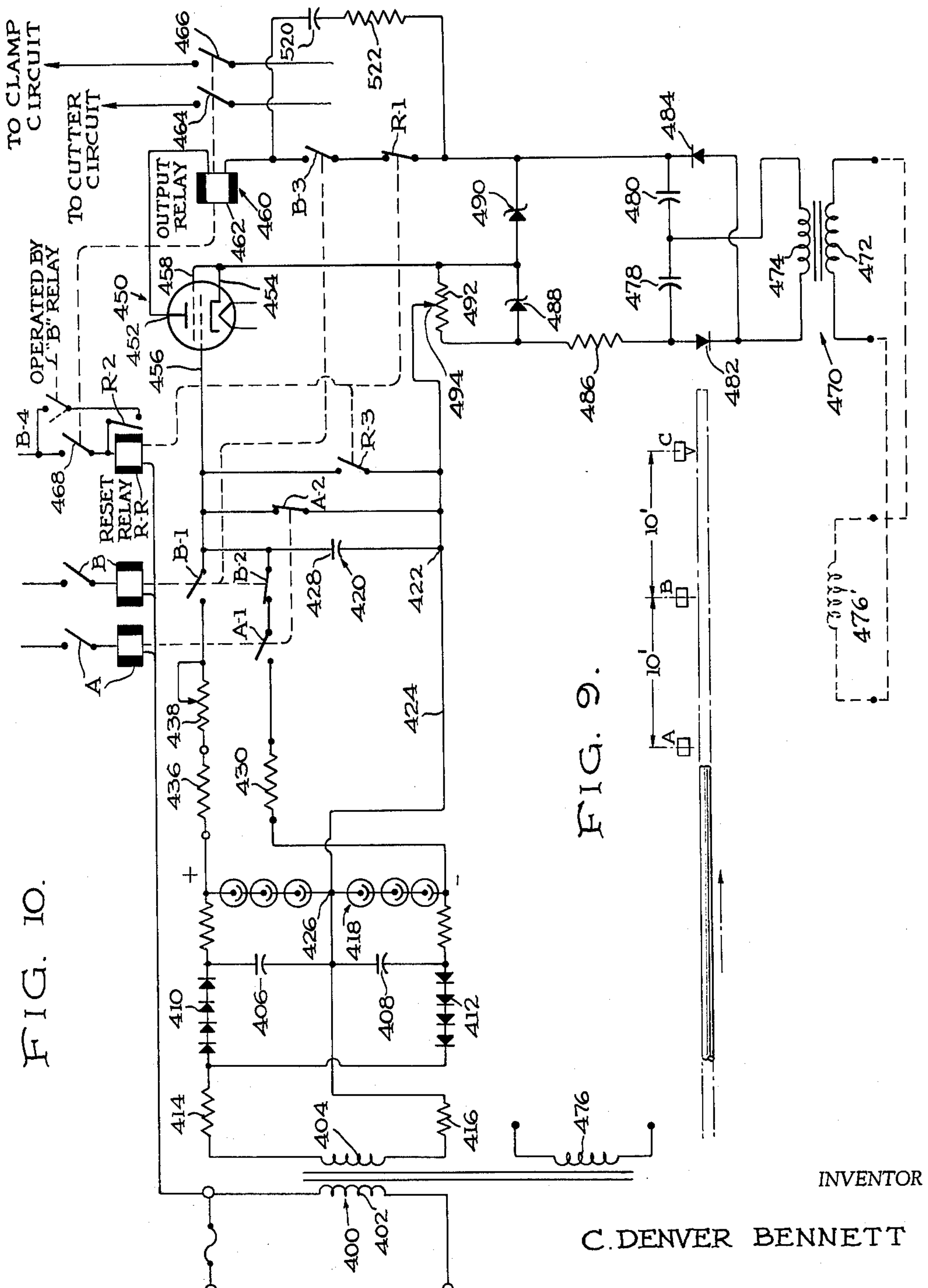

FIG. 10.

FIG. 9.

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ELECTRONIC TIMING AND CUTTING APPARATUS

Filed Nov. 5, 1962 5 Sheets-Sheet 5

FIG. 11.

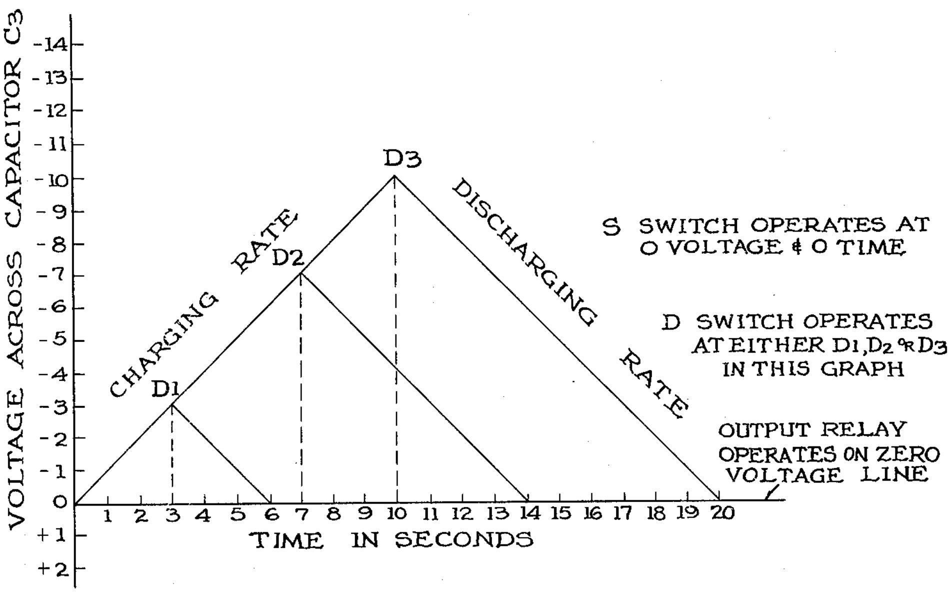
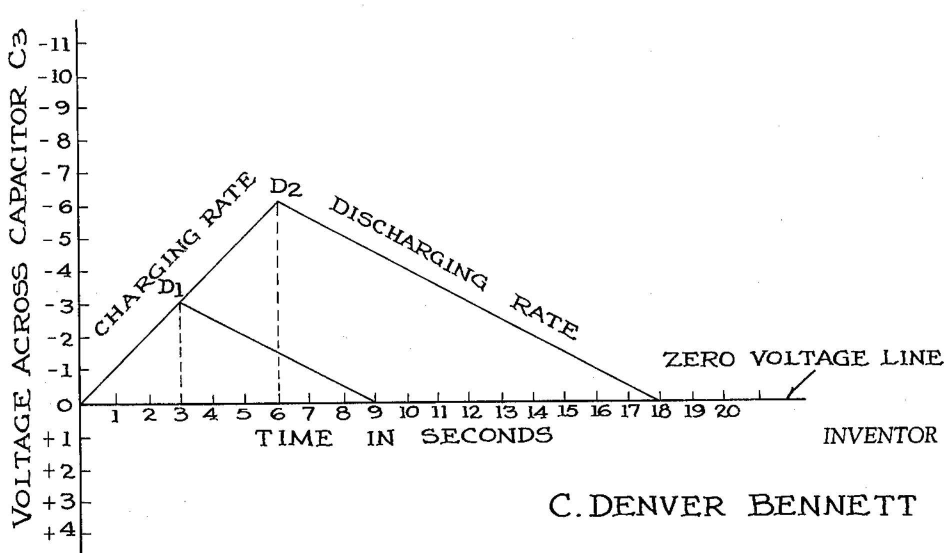


FIG. 12.



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United States Patent Office

3,211,036
Patented Oct. 12, 1965

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3,211,036
ELECTRONIC TIMING AND CUTTING APPARATUS

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Filed Nov. 5, 1962, Ser. No. 235,567
6 Claims. (Cl. 83—210)

This invention relates to an apparatus for and method of measuring and dividing lengths of longitudinally moving members, such as pipes, rods, sheets, extrusions, and the like, into predetermined fractional lengths, such as halves or thirds, or into predetermined fixed lengths, as desired, or for "cropping" predetermined lengths from the ends of such members, and to electronic timing circuits useful for accomplishing the purposes just described. This application is a continuation-in-part of my prior pending application Serial No. 160,216, filed December 18, 1961.

In the metal processing industry there is a great need for apparatus for subdividing lengths of longitudinally moving materials such as pipes, rods, and the like into predetermined fractional lengths or into predetermined fixed lengths. However, the apparatus which has been provided in accordance with the prior art for accomplishing this purpose has been unsatisfactory in many respects. Thus, for example, the prior art apparatus generally has been very complicated, involving the use of great numbers of electronic tubes and relays which necessitated large financial outlays for their initial installation and which also presented many maintenance problems. The prior art apparatus has also been functionally inadequate in some respects, as, for example, being incapable of recognizing a pipe length which is too short to be cut into fractions such as halves and instead cutting such pipe into two equal pieces each of which is too short and can be used only as scrap. Furthermore, the complexities of the prior art apparatus generally have been such that only highly skilled electronic technicians are capable of effecting the necessary repairs when a breakdown occurs on such apparatus.

It is also frequently necessary in the metal processing industry to "crop" predetermined lengths from the ends of longitudinally moving materials such as pipes, rods, and the like, for various reasons, as, for example, because of off-gauge, rough, or irregular ends on the moving members.

Accordingly, it is an object of this invention to provide an apparatus for and method of cutting lengths of longitudinally moving objects, such as pipes, rods, sheets, and the like, into predetermined fractional lengths or into predetermined fixed lengths, with the apparatus being such as to require only low first cost and little maintenance.

It is another object of this invention to provide an apparatus for cutting pipes, rods, and the like, which is relatively uncomplicated compared to the prior art apparatus for this purpose and which has fewer parts than the prior art apparatus.

It is another object of this invention to provide an apparatus for subdividing pipes, rods, and the like, which includes electronic circuitry which is relatively simple compared to prior art apparatus for accomplishing this purpose, and which includes relatively simple controls for adjusting the apparatus for varying operating conditions.

Still another object of the invention is to provide an apparatus for subdividing pipes, rods, and the like, which is reliable and efficient in its operation and which is capable of sensing when the rod or pipe is too short to be subdivided thereby to insure that at least one usable length is produced from a pipe which is too short for subdivision, rather than a plurality of fractional lengths, none of which is equal to the minimum length required.

2

It is another object of the invention to provide an apparatus and method which can be used either for cutting longitudinally moving lengths of pipes, rods, sheets, and the like into predetermined fractional lengths or into repeating fixed lengths as desired.

Still another object of the invention is to provide an apparatus of the type hereinabove described which operates with a high degree of accuracy in cutting the pipes or the like into fractional lengths or into fixed lengths.

Still another object of the invention is to provide an apparatus of the type hereinabove described in which the pipe or the like can be cut into predetermined fractional lengths or into predetermined fixed lengths regardless of whether the pipe travels at a constant speed or at a variable speed.

Still another object of the invention is to provide an apparatus and associated electronic circuitry for cropping predetermined lengths from the ends of longitudinally moving material to eliminate off-gauge, rough, or irregular ends.

In achievement of these objectives, there is provided in accordance with this invention an apparatus for and method of measuring and dividing lengths of longitudinally moving material such as pipes and the like into either predetermined fractional lengths or predetermined fixed lengths. The apparatus includes a timing circuit having a capacitor which is charged through a current limiting impedance to the predetermined trigger voltage of a gaseous discharge thyratron tube or other equivalent electronic control device to cause the thyratron tube to fire and actuate a cutting and clamping device at the moment when the midpoint or other predetermined point of the longitudinally moving material arrives at the cutter. Suitable sensing devices, preferably proximity switches, are positioned adjacent the path of movement of the material being cut to cause the timing capacitor to begin charging when the leading end of the material being cut reaches the cutting device, and also to control the rate of charging of the timing capacitor as a function of the length of the material to compensate for variations in length of material being cut from a predetermined minimum length.

The timing apparatus of the invention also may be used for cutting predetermined fixed lengths of moving material, rather than predetermined fractional lengths, if desired. The timing device may be used also for other types of measuring or timing operations and is not restricted to use in apparatus for cutting moving material.

Another embodiment of the invention is provided for cropping predetermined lengths from the ends of the moving material, such as pipes or the like. The moving member which is to be cropped actuates a first sensing switch to produce a first signal when the forward end of the material reaches a predetermined point along the path of movement, and actuates a second sensing switch to produce a second signal when the forward end reaches a second predetermined point further along the path of movement of the material. The first signal produced by the moving member initiates a capacitor charging operation, while the second signal initiates a capacitor discharging operation. In accordance with the invention, separate charging and discharging circuits are provided for the storage capacitor in such manner that the rate of discharge can be varied relative to the rate of charging of the capacitor to thereby control the interval required for the capacitor to discharge to the same potential level as that at which the charging operation began. This adjustable relation of the discharge rate to the charging rate of the capacitor is utilized to determine the time lapse before the actuation of a control means such as a thyratron gaseous discharge tube which controls the "cropping" of the moving member. With the charging and discharging rates of the capacitor being adjusted to have a predetermined ratio to each other, the length of material cropped from each piece of moving material remains the same regardless of the speed of the moving material as long as the speed of the moving material remains constant.

Throughout the specification, the material which is being subdivided will be referred to as a pipe for simplicity in description. However, it will be understood that the term "pipe" is used as representative of any moving material which is to be cut, such as pipes, rods, sheets, extrusions, or the like.

Further objects and advantages of the invention will become apparent from the following description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a schematic view showing the apparatus of the invention employed for cutting longitudinally moving pipe into predetermined fractional lengths or into predetermined fixed lengths;

FIG. 2 is a simplified schematic diagram illustrating the timing device of the invention used for controlling the cutting into two equal lengths of a longitudinally moving pipe or the like which moves at a constant speed;

FIG. 3 is a schematic view showing the relation of the pipe which is to be cut into two equal lengths to the S and D control switches when the pipe to be cut is just equal in length to the minimum length of pipe to be cut for the given setting of the S and D switches;

FIG. 4 is a schematic view showing the relation of the pipe to be cut to the S and D switches when the pipe length before cutting exceeds the minimum length of pipe to be cut for the given setting of the S and D switches;

FIG. 5 is a complete schematic diagram of the timing circuit of the invention used for controlling the cutting into two equal lengths of a longitudinally moving pipe or the like which moves at a constant speed, the simplified schematic diagram of which was shown in FIG. 2;

FIG. 6 is a simplified circuit diagram of a timing circuit used for subdividing a longitudinally moving pipe or the like into three equal lengths where the pipe moves at a constant speed;

FIG. 7 is a schematic view showing the relation of the pipe to be cut to the S switch and to the ½D and ⅓D switches when the pipe which is to be cut into three equal lengths is just equal in length to the minimum length of pipe to be cut for the given setting of the S and ½D and ⅓D switches;

FIG. 8 is a complete schematic diagram of the timing circuit used for controlling the cutting into two equal lengths of a pipe which is moving at a variable speed;

FIG. 9 is a schematic diagram showing the relation of the pipe to be cropped to the A and B switches and to the cutter member;

FIG. 10 is a schematic diagram of the timing circuit used for controlling the cropping of predetermined lengths from the ends of longitudinally moving pipe or the like which moves at a constant speed;

FIG. 11 is a graph which compares the charging rate with the discharging rate of the storage capacitor when the constant of the timing circuit is one; and

FIG. 12 is a graph which compares the charging rate with the discharging rate of the storage capacitor when the constant of the timing circuit is one-half.

Referring now to FIG. 1 which shows schematically the orientation of the various parts of the apparatus relative to the longitudinally moving pipe P which is being cut, there are shown a plurality of longitudinally spaced pedestals or other suitable conveyor supports generally indicated at **10**, **12**, **14**, and **16** on which are mounted conveyor rolls **18**, **20**, and **22**. Certain of the conveyor rolls, such as rolls **20** and **22** at opposite ends of the roll conveyor structure, are driven by power drive means such as the motor-driven drive shafts **24** and **26**, respectively.

A length of pipe P is supported for movement along the plurality of rolls **18**, **20**, **22**, the rolls being V-shaped or otherwise suitably shaped to receive the pipe being transferred. A cutter **28** is suitably supported in overlying relation to the moving pipe at a point midway between pedestals **12** and **14**. Clamp members **30** are positioned on either side of the pedestals **12** and **14** in position to clamp the pipe and stop the motion thereof when the cutter **28** is energized to cut the pipe at the predetermined fractional length or predetermined fixed length as will be explained hereinafter.

In order to control the clamping and cutting operation when a predetermined fractional length or a predetermined fixed length has passed by the cutter **28**, a pair of sensing switches S and D are provided. When the pipe is to be cut into two equal lengths, the S and D switches are spaced apart a distance corresponding to the minimum length before cutting of the pipe which is to be cut. Thus, for example, if a 100-foot length of pipe is the minimum length of pipe to be cut, the S and D switches are spaced apart 100 feet along the path of movement of the pipe. The S switch is positioned at the same position as the cutter along the path of travel of the pipe, while the D switch is displaced from the S switch in the direction of the trailing end of the pipe by a distance equal to the length before cutting of the minimum length of pipe to be cut. The spacing between the S and D switches varies for different fractional cuts and the explanation just given of the positions of the S and D switches applies only where the pipe is to be cut into two equal lengths.

The S and D switches are preferably switches of the proximity type which do not require actual contact with the moving material. Proximity switches are well known in the art and may operate either on the inductive or capacitative principle. The use of proximity switches for this purpose is preferred due to the fact that it avoids wear on the switches. However, switches of the type which actually are in contact with the moving pipe may be used if preferred.

The S switch is actuated at the instant that the leading end of the pipe passes by it, closure of the S switch energizing the S relay and operating the normally closed contact S′ to open position to start a capacitor charging operation, the length of time required to charge the capacitor determining the time of firing of a thyratron gas tube which controls the pipe elements and cutting operations.

The D switch is actuated by the presence of a pipe adjacent thereto, the length of time that the D switch is actuated after the initial actuation of the S switch by the leading end of the pipe being a measure of the length of the pipe in excess of the minimum pipe length for which the S and D switches are set. Actuation of the D switch by the presence of a pipe actuates the D relay to open the normally closed D′ contact which is connected in shunting relation to limiting resistance in the capacitor charging circuit, the D′ contact continuing to remain open as long as the pipe continues to pass by the D switch. The opening of the shunting D′ contact by actuation of the D switch increases the time required to charge the capacitor which controls the time of firing of the thyratron control tube, thereby increasing the time interval before actuation of the pipe clamping and cutting devices, as will be described hereinafter.

Referring now to FIG. 2 of the drawings, there is shown a simple schematic diagram illustrating the principle of the timing and control circuit used for subdividing a longitudinally moving pipe or the like into two equal lengths. The timing circuit includes a gaseous discharge tube of the thyratron type, preferably a 2D21W thyratron generally indicated at **40**, including anode **42**, cathode **44**, a control grid **46**, and also a screen grid **48**, which is connected to cathode **44**. The operating coil **52** of a relay generally indicated at **50** is connected in the output circuit of anode **42**. Relay **50** includes two normally open contacts **53** and **54** which are actuated to closed position by energization of relay operating coil **52** due to current flow in the circuit of anode **42** when the thyratron tube **40** fires. Contacts **53** and **54** are respectively in the circuits of solenoids **56** and **57**. Closure of contact **53** is effective to energize solenoid **56** to actuate clamps **30** to a position in which the pipe P is clamped against movement to permit cutting of the pipe. Closure of contact **54** is effective to energize solenoid **57** to actuate cutter **58** to cut the pipe.

Since it is a characteristic of gaseous discharge thyratron tubes that once firing of the tube has occurred the control grid loses control, it is necessary to open the anode circuit to cause the tube to revert to an open circuit condition in which the control grid again has control. To open the anode circuit as just described and thus reset the tube for the next cutting operation, a reset relay generally indicated at **60** is provided. Reset relay includes an operating coil **61** which controls a normally closed contact **62** in the anode circuit of tube **40**. Operating coil **61** of reset relay **60** is energized by closure of contact **64** upon the completion of the pipe cutting operation, contact **64** being actuated to closed position by movement of cutter **58** to a position indicative of completion of the cutting operation. Energization of the operating coil **61** of reset relay **60** opens normally closed contact **62** in the anode circuit of tube **40** thereby to reset the tube for another cycle of operation.

It is a well-known characteristic of thyratron gaseous discharge tubes that a certain predetermined anode potential the tube will fire or become conductive when a predetermined trigger voltage is applied to the control grid of the tube. In the timing circuit of FIG. 2, the time required for the thyratron tube **40** to reach the trigger voltage is controlled through a resistance-capacitance timing circuit including a capacitor **66** connected between grid **46** and cathode **44**. Capacitor **66** is connected across a constant voltage regulated D.C. supply at terminals **68** and **70** in series with a limiting resistor generally indicated at **72**, including two equal series-connected resistance sections **73** and **74**. In accordance with an important feature of the invention, the contacts S′ and D′ previously referred to are connected in the timing in a manner which will now be described.

The S′ contact is placed in parallel with capacitor **66** so that the charging of the capacitor through resistors **73** and **74** does not begin until the S switch adjacent the path of movement of the pipe has been actuated by the passage adjacent thereto of the pipe which is to be cut to cause the S relay to move contact S′ from its normally closed position to open position. Opening of the S′ contact removes the short circuit shunt path which had existed across capacitor **66** when contact S′ was closed, and permits capacitor **66** to begin charging.

The D switch which, in the embodiment of FIGS. 2–5 is mounted a distance from the S switch equal to the minimum length of pipe which is to be cut, or a distance equal to twice the length of the cut which is to be made, actuates the D relay to open the normally closed D′ contact when pipe is passing adjacent the D switch. The D′ contact is connected in parallel or shunting relation with the resistance section **74**, which, as previously stated, is identically equal in resistance value to resistance section **73** and thus equal to exactly one-half the total resistance **72**. Thus, when the D switch is actuated due to the presence of pipe passing adjacent thereto, normally closed contact D′ is opened by the D relay, and both resistance sections **73** and **74** are connected in series relation with capacitor **66**. On the other hand, if no pipe is adjacent the D switch, the D relay is deenergized to permit reclosing of the normally closed D′ contact.

If the circuit constants are so adjusted, for example, that it takes 10 seconds for the capacitor **66** to charge up to the trigger voltage on tube **40**, when contact D′ is closed and only half the limiting resistance **72** is in series with capacitor **66** then it would take 20 seconds to build up to the same trigger voltage if switch contact D′ is open and both of the equal resistance sections **73** and **74** were in series with capacitor **66** for the entire charging period. Similarly, for any portion of the charging period of capacitor **66** during which contact D′ is closed, the charging rate of capacitor **66** will be twice as great as during the portions of the charging period when contact D′ is open.

In accordance with the invention, the relationship of the opening and closing of contact D′ to the total time required to charge capacitor **66** to the trigger voltage of tube **40** is used to measure the length of a pipe or the like which is to be cut and to so control the charging period of capacitor **66** as to cause the trigger voltage on grid **46** of the tube **40** to be reached after an interval such that the clamping and cutting action will occur precisely when the midpoint of the pipe reaches the cutter, thereby to cut each pipe into two equal lengths. The timing and control circuit of FIG. 2 operates to cut the pipe into two equal lengths as long as the length of the pipe is between the minimum length for which the S and D switches are set, at one extreme, and twice the minimum length at the other extreme. Thus, for example, if the S and D switches are set for a minimum pipe length before cutting of 100 feet, the timing and control circuit will cut the pipe into two equal lengths as long as the pipe length before cutting is in the range 100 feet–200 feet.

Several specific examples of the operation of the timing circuit of FIG. 2 now will be described. Assume first that a pipe exactly 100 feet in length is to be cut in half. As will be seen from FIG. 3, the 100-foot pipe exactly spans the length between the S switch adjacent the leading end of the pipe and the D switch adjacent the trailing end of the pipe. Assume that the pipe travels longitudinally on the rolls **18**, **20**, and **22** at a constant speed of 5 feet per second. Assume that the value of the limiting resistors **73** and **74** has been adjusted so that with both resistor sections **73** and **74** connected in series with capacitor **66** for the entire charging period, the time required to charge capacitor **66** to the trigger voltage of tube **40** is 20 seconds whereas only 10 seconds is required to charge capacitor **66** to the trigger voltage of tube **40** if only resistor section **73** is in series with capacitor **66** for the entire charging period of capacitor **66**. The minimum length of pipe to be cut and the rate of movement of the pipe are factors in selecting the resistance and capacitance values which control the charging time required to reach the trigger voltage on the thyratron tube.

As soon as the leading end of the 100-foot pipe P in FIG. 3 reaches the S switch, switch S actuates the S relay to open contact S′ to permit capacitor **66** to begin charging through the limiting resistance. Since at the same instant that the leading end of pipe P reaches switch S, the trailing end of the pipe is just passing out of contact with switch D at the trailing end of the pipe, contact D′ controlled by relay D is closed and shunts out resistor section **74**. Resistor **73** and capacitor **66** have their values so related that when the charging circuit is only through resistor **73** for the entire charging period, capacitor **66** will be charged to the trigger voltage of tube **40** in 10 seconds. During this 10-second period, which begins when the leading end of pipe P actuates switch S, the pipe will move 50 feet beyond the S switch and beyond the cutter, since the rate of movement of the pipe is 5 feet per second. Thus, at the end of the ten-second interval required to charge capacitor **66** with only resistor **73** in circuit, tube **40** will fire and current conduction in the circuit of anode **42** will energize operating coil **52** of output relay **50**. Energization of coil **52** will close normally open relay contacts **53** and **54** which are respectively in the electrical circuit of the clamps **30** and cutter **58** to energize elements, such as solenoids **56** and **57**, in the respective electrical circuits of clamps **30** and cutter **58**. The energization of the electrical circuits of the clamps and cutter causes the clamps to clamp the moving pipe against movement and causes the cutter to cut the pipe in two equal lengths. Upon completion of the cutting operation, contact **64** is closed by cutter **58** to energize operating coil **61** of reset relay **60**. Energization of reset relay coil **61** opens normally closed contact **62** in the circuit of anode **42** thereby to reestablish control of the tube **40** by grid **48** to reset the timing circuit for the next timing operation.

Now, assume that a pipe 110 feet long is to be cut rather than the 100-foot pipe previously described. Assume, as before, that the pipe is moving at a constant rate of speed of 5 feet per second. In this case, when the leading end of the pipe causes the opening of the S' contact to begin charging of capacitor **66**, the trailing end of the pipe still extends 10 feet rearwardly of the D switch. Hence, since the rate of movement of the pipe is 5 feet per second, it will take the trailing end of the pipe 2 seconds to reach the D switch. During the 2 seconds that the trailing end of the pipe is moving to reach the D switch, the D' contact is maintained open by the D relay controlled by the D switch. With the D' contact open, both of the equal resistor sections **73** and **74** are in series with the capacitor **66** for a period of 2 seconds. Hence, during this 2-second interval capacitor **66** is charging at one-half the rate that it would if only the resistor **73** were in series therewith.

It can be shown that the total time required to charge capacitor **66** to the trigger voltage of the thyratron tube can be calculated according to the following formula:

$$T_a = T_1 + \frac{T - T_1}{2}$$

where

T_a is the actual total charging time required to reach the trigger voltage of the thyratron tube **40**

T_1 is the time during the charging period during which both the equal resistor sections **73** and **74** are connected in the charging circuit of capacitor **66**

T is the charging time required to reach the trigger voltage of tube **40** if both resistor sections **73** and **74** were in the charging circuit for the entire charging period.

Since in the assumed example, the pipe to be cut is 110 feet in length, T_1, the time during the charging period during which both resistors **73** and **74** are connected in the charging circuit, is 2 seconds, since 2 seconds are required for the 10 feet of the pipe which projects beyond the D switch to pass the D switch, during which 2-second period the D switch remains open to cause both resistors **73** and **74** to be connected in the charging circuit of capacitor **66**. T is assumed to be 20 seconds in the assumed example.

Substituting the values just given into the equation:

$$T_a = 2 + \frac{20 - 2}{2} = 2 + 9 = 11$$

Therefore, solution of the equation indicates that 11 seconds charging time is required to charge the capacitor **66** to the trigger voltage of tube **40**, at the end of which interval tube **40** becomes conducting to energize output relay **50** to actuate clamps **30** and cutter **58**. Since by definition the pipe is moving at the rate of 5 feet per second, the pipe would have moved 55 feet beyond the S switch at the time the thyratron tube **40** fired, which would be the exact midpoint of the 110-foot length of the pipe. Thus it can be seen that the timing circuit automatically computes the length of the pipe and causes the actuation of the clamping and cutting devices at the time the exact midpoint of the pipe reaches the cutter.

Reference now is made to FIG. 5 which shows a complete schematic of the circuit used for dividing pipe lengths and the like into two equal lengths. The power supply for the timer circuit is derived from an alternating current input supply which may have, for example, a voltage rating of 117 volts. The input voltage is applied to the primary winding **102** of a transformer generally indicated at **100**. The voltage of transformer secondary winding **104** is applied across a voltage doubling circuit including capacitors **106** and **108** and silicon diode rectifiers **110** and **112**. The D.C. output voltage of the voltage doubling circuit is derived at terminals **114** and **116** and is applied to a voltage regulating circuit including a limiting resistor **118** and a plurality of series-connected neon bulbs generally indicated at **120** which maintain a constant output voltage across their terminals. The timing capacitor **126** which is to be charged is connected across the output terminals **122** and **124** of the neon voltage regulator tubes **120** in series with four current limiting resistors **128**, **130**, **132**, and **134**. Adjusting taps **136** are provided for the resistors **130** and **132** to provide adjustment of the resistance values when required.

The normally closed D' contact is connected in shunting relation to resistors **132** and **134** which are of equal magnitude to the resistors **128** and **130**, so that when the D' contact is in its normally closed position only one-half of the total resistance value of resistors **128–130–132–134** is included in series with capacitor **126**.

The normally closed S' contact is connected in parallel shunting relation to timing capacitor **126** so that when the S' contact is in normally closed position, timing capacitor does not charge.

The thyratron gas tube **140** includes an anode **142**, a cathode **144**, and a control grid **146**. Control grid **146** is connected to one terminal of capacitor **126** in series with a neon bulb **148** which conducts only when a predetermined voltage, such as 60 volts, is applied across its terminals. A bias voltage is supplied to control grid **146** from secondary winding **152** of a transformer **150**, the primary winding **151** of transformer **150** being connected to the secondary winding **105** of supply transformer **100**. The biasing voltage supply circuit for grid **146** includes a voltage doubling circuit having capacitors **154** and **156** and diode rectifiers **158** and **160** connected across the secondary winding **152** of transformer **150**. A voltage regulating neon bulb **162** is connected across the output terminals of the voltage divider in series with a current limiting resistor **164**. Neon bulb **162** provides a stable D.C. voltage output which is applied in series with resistors **166** and **168** across bias resistors **170** and **172** which control the bias voltage of control grid **146**.

Current conduction occurs through neon bulb **148** only when the voltage across bulb **148** builds up to a certain value, such as 60 volts. The instant that neon bulb **148** becomes conductive, a positive pulse is applied to the grid **146** of thyratron tube **140** to cause the tube to fire thereby to energize output relay **190**. If the voltage across the resistors **170** and **172** is adjusted, for example, to 30 volts, the voltage across the capacitor **126** need build up to only 30 volts because the voltages across timing capacitor **126** and across resistors **170** and **172** are in series across neon bulb **148**. Thus, if the voltage across resistors **170** and **172** is 30 volts, then 30 volts voltage drop across capacitor **126** is sufficient to discharge neon tube **148** to apply a positive pulse to grid **146** to cause firing of tube **140**.

The anode **142** of tube **140** derives its D.C. voltage supply from a voltage doubler circuit supplied from secondary winding **178** of transformer **150**, the voltage doubled circuit including capacitors **180**, **182**, and diode rectifiers **184** and **186**.

The operation of the circuit in accordance with the complete schematic diagram of FIG. 5 is substantially like that described in connection with the simple schematic diagram of FIG. 2. When the leading end of the pipe to be cut moves adjacent the S switch, the S relay is actuated to cause normally closed contact S' to open to permit capacitor **126** to start charging. The rate of charging of capacitor **126** depends upon whether or not the D′ contact, which is in shunt with resistor sections **132** and **134**, is open or closed, as previously explained. This, in turn, depends upon how much of the length of the pipe to be cut projects beyond the D switch, all as previously explained. When the voltage on capacitor **126** reaches a value such that this voltage plus the voltage across biasing resistors **170** and **172** is sufficient to cause conduction through neon bulb **148**, neon bulb **148** fires and thus applies a positive pulse to the control grid **146** of the thyratron tube **140**. Upon firing of tube **140**, the output relay **190** in the circuit of anode **142** is energized thereby to actuate contacts in the cutter control circuit and in the clamp control circuit to cause clamps **30** to clamp the pipe and to cause the cutter to cut the pipe at its midpoint. Upon completion of the cutting operation, the reset relay circuit is energized to open normally closed contact **192** in the anode circuit of tube **140** thereby to reset the tube for another cycle of operation.

While the timing circuit and the position of the S and D switches shown in the embodiment of FIG. 5 have been arranged to control cutting of the pipes or other moving material into two equal lengths, the timing circuit and the position sensing switches also may be arranged to cause some other fraction of the total length of the pipe to be cut if desired. FIGS. 6 and 7 show the circuit of the timing device and the location of the position sensing switches used when the pipe or other moving material is to be cut into three equal lengths. In using the timing circuit of FIG. 6 to cut a pipe into three equal lengths, the maximum length of the pipe to be cut must not exceed 150 percent of the minimum length of the pipe to be cut.

In cutting the pipe or the like into three equal lengths, three switches are used to sense the position of the pipe relative to the cutter, namely the S switch, the ½D switch, and the ⅓D switch. Each of these switches is connected in series with a relay, these relays being respectively indicated as the S relay, the ½D relay, and the ⅓D relay. The S switch is positioned at the same point along the path of movement of the pipe as the cutter, and is first actuated by the leading end of the pipe, as described in the previous embodiments. The ⅓D switch is positioned a distance from the S switch equal to the length before cutting of the shortest pipe which is to be cut. Thus, if a pipe having a minimum length of 100 feet is to be cut into three equal lengths, the ⅓D switch is positioned 100 feet from the S switch in the direction of the trailing end of the pipe. The ½D switch is positioned a distance from the S switch equal to two-thirds the distance of the ⅓D switch from the S switch or, in the example shown in FIG. 7, the ½D switch is positioned a distance of 66⅔ feet from the S switch.

The ⅓D relay, operated by the ⅓D switch, controls a normally closed contact **228** and a normally open contact **230**, the connection of which will be explained hereinafter. The ½D switch controls the actuation of a normally closed contact **234**.

The timing circuit shown in FIG. 6 for timing the cutting of a pipe into three equal lengths includes a thyratron gas tube generally indicated at **200**, including an anode **202**, a cathode **204**, and a control grid **206**. An output relay **205** is connected in the circuit of anode **202** to operate contacts in the electrical circuits of the clamps and cutter as previously described in connection with the embodiments of FIGS. 2–5. A reset contact **207** also is connected in the circuit of anode **202** as previously explained. A capacitor **212** is connected between control grid **206** and cathode **204**, and a normally closed S switch is connected in parallel with capacitor **212**. Four resistor sections **214–216–218–220**, each of equal magnitude, are connected in series with capacitor **212** across the terminals **208** and **210** of a regulated constant D.C. voltage supply.

As seen in FIG. 6, two shunt paths are provided in parallel with each other across the two series-connected resistor sections **218–220**, these two resistor sections comprising one-half of the total resistance of resistor sections **214–216–218–220**. The first of these shunt paths includes the normally closed contact **228** which is operated to open position when the ⅓D relay is energized by the presence of the pipe adjacent the ⅓D switch. Contact **228** is connected in series in the first shunt path with a normally closed contact **236** which is actuated to open position upon the energization of the output relay **205** in the circuit of anode **202** of thyratron tube **200**. The second shunt path across resistor sections **218–220** includes the normally closed contact **234** which is actuated to open position when the ½D relay is energized by the presence of the pipe adjacent the ½D switch.

A separate shunt path is provided across resistor section **220** by normally open contact **230** which is operated to closed position when the ⅓D relay is energized by the presence of the pipe adjacent the ⅓D switch.

The timing circuit of FIG. 5 and the position sensing switches shown in FIG. 6 cooperate to effect the division of the pipe into three equal lengths in two separate measuring and cutting operations, as follows:

(1) Measurement of the pipe to determine when ⅓ of the length thereof has passed by the cutter, and actuation of the clamps and cutter to make a cut at a point corresponding to ⅓ of the length of the original pipe.

(2) Measurement of the length of the remaining ⅔ of the original pipe length and actuation of the clamps and cutter to make a cut at the midpoint of the remaining ⅔ of the pipe length, or, in effect, cutting the remaining ⅔ of the pipe length into two equal lengths. This portion of the cutting operation involves use of a timing circuit similar to that used in the embodiment of FIGS. 2–5.

The shunt path connections across the limiting resistor **220** and across resistors **218–220** established by the selective opening and closing of the various contacts **228–230–234–236** permits the completion of the two sequential steps just described and provides what might be termed a dual ratio timing device.

In explaining the operation of the circuit of FIG. 5, it will first be assumed that a pipe having a length greater than 100 feet is to be cut into three equal lengths, and that the pipe moves along the conveyor rolls at a constant rate of speed of 5 feet per second. It is also assumed that the position sensing switches are set for a minimum length of pipe, before cutting, of 100 feet, with the ⅓D switch being positioned 100 feet from the S switch, and with the ½D switch being positioned 66⅔ feet from the S switch and 33⅓ feet from the ⅓D switch.

Cutting the first one-third of the pipe

With the conditions as just assumed, when the leading end of the pipe has moved along the conveyor rolls to a point where it is opposite the S switch, the trailing end of the pipe is still at a point beyond the ⅓D switch. When the leading end of the pipe is adjacent the S switch, the S switch is actuated to energize the S relay to open the S′ contact connected in parallel with capacitor **212**, thereby to permit charging of capacitor **212** to begin. Since, at the same time, the pipe also is moving adjacent the ½D switch and the ⅓D switch and extends beyond the ⅓D switch, both the ½D switch and the ⅓D switch are actuated to energize the ½D relay and the ⅓D relay. Energization of the ½D relay opens the normally closed contact **234** to open one of the shunt paths across resistor sections **218** and **220**. Energization of the ⅓D relay opens the normally closed contact **228** to open the other shunt path across resistor sections **218–220**. Energization of the ⅓D relay also closes the normally open contact **230**. Thus, both of the shunt paths across resistor sections 218 and 220 are open, but the shunt path across resistor section 220 through contact 230 is closed. Therefore, with both the ⅓D relay and the ½D relay energized, the current flow to charge capacitor 212 is through limiting resistors 214–216–218.

After the pipe has moved beyond the ⅓D switch but is still in contact with the ½D switch, and assuming that the charge on capacitor 212 has not reached the trigger voltage of the thyratron tube, the ⅓D switch is deactivated to deenergize the ⅓D relay, thereby to open contact 230 and close contact 228. Also, since the pipe by definition must be within the length limits of 100–150 feet, assuming that the minimum length is 100 feet in the example, the trailing end of the pipe will not reach the ½D switch before the first one-third cut is made. Therefore, during the entire interval before the first one-third cut is made, the ½D relay remains energized to maintain contact 234 open. Thus, when the trailing end of the pipe has passed the ⅓D switch but has not reached the ½D switch, and assuming that thyratron tube 200 has not fired, the shunt path through contact 230 is open and the shunt path through contact 234 is open. However, the shunt path through the series-connected contacts 228–236 is closed, thereby causing resistor sections 218 and 220 to be shunted. Thus, the charging circuit to capacitor 212 under these conditions is through resistor sections 214 and 216. This causes the ratio of the charging current to capacitor 212 to be 1.5 times as great as it was when the charging circuit was through resistor sections 214–216–218.

To summarize, if the length of the pipe is greater than the minimum length of pipe to be cut, and not greater than one and one-half times the minimum length, both of the following conditions may occur during the first one-third of the travel of the pipe:

(1) With the pipe adjacent both the ⅓D switch and the ½D switch, the ⅓D relay and the ½D relay are both energized. With both of these relays energized, the only shunt path is through closed contact 230 which shunts out resistor section 220, thereby causing the capacitor 212 to be charged through resistor sections 214, 216, and 218.

(2) If the pipe has passed the ⅓D switch, but is still in contact with the ½D switch, and one-third of the length of the pipe has not yet passed the S switch to cause firing of thyratron tube 200, only the ½D relay will be energized. With this condition of the relays, contact 230 of the ⅓D relay will be open and contact 228 of the ⅓D relay will be closed, and contact 234 of the ½D relay will be open. Therefore, the shunt path will be closed through contacts 236 and 228 across resistor sections 218 and 220. This causes capacitor 212 to be charged through resistor sections 214 and 216, and the current flow through these two resistor sections will have a ratio of 1.5 to 1 to the current flow which occurred through the three resistor sections 214, 216, and 218. Therefore, capacitor 212 will charge 1.5 times as fast during the period of the first ⅓ cut when the pipe has passed out of contact with the ⅓D relay as it did when the pipe was still passing adjacent the ⅓D relay.

When the capacitor 212 finally becomes charged to a potential sufficient to trigger the firing of thyratron tube 200, the current flows through output relay 205 and closes contacts in the control circuits for the clamps and for the cutter to cause the pipe to be clamped and to cause the cutter to cut the pipe at one-third of its length. When the cutting operation is completed, the cutter closes a contact which energizes a reset relay to open the reset contact 207 in the anode circuit of tube 200, as previously explained in connection with the embodiment of FIGS. 2–5. Also, the energization of the output relay 205 opens the contact 236 in series with normally closed contact 228 of the ⅓D relay. The operation of contact 236 is such that it does not revert to closed position when thyratron tube 200 stops conducting, but instead must be reset to closed position by appropriate means when the next pipe is to be cut.

Cutting the remaining ⅔ of the pipe in half

Upon the opening of reset contact 207 at the completion of the cutting and clamping operation to cause deenergization of the thyratron tube, the cutter is retracted from cutting position and the clamps are released from clamping engagement with the pipe. The pipe which has now had one-third of its length severed begins to move again. The circuit of FIG. 5 now provides a timing and control action which causes the remaining two-thirds of the pipe to be cut into two equal lengths, thus resulting in a severing of the original pipe into three equal lengths.

Since the ⅓D switch is open due to the fact that the pipe, being within the length limits previously specified and already having ⅓ of its length severed therefrom, can no longer be adjacent the ⅓D switch, the ⅓D relay is deactivated to close contact 228 and to open contact 230. However, if the original length of the pipe was greater than the minimum length, the pipe after the first ⅓ cut still would be adjacent the ½D switch to continue actuation of the ½D relay and to maintain contact 234 open. With contacts 230, 234, and 236 all open as just described, all of the shunt paths across resistor sections 218 and 220 are open.

Thus, for the portion of the length of the remaining two-thirds of the original pipe length which projects beyond the ½D switch, all four resistors 214, 216, 218 and 220 are in the charging circuit of capacitor 212. As soon, however, as the trailing end of the pipe passes the ½D switch, the ½D relay is deenergized, causing the normally closed contact 234 to reclose, thereby establishing a shunt circuit across resistor sections 218 and 220. With contact 234 closed, only resistor sections 214 and 216, which have a resistance equal to one-half the value of the total resistance 214–216–218–220, are in the charging circuit of capacitor 212, and the capacitor 212 therefore charges at twice the rate that it did when the shunt circuit through contact 234 was open. When the capacitor 212 becomes charged to the trigger voltage of tube 200, the tube fires and energizes relay 205 to cause actuation of the clamps and of the cutting device as previously explained, thereby to effect the cutting of the remaining two-thirds of the length of the pipe into equal halves. Thus, by the use of the dual ratio timing circuit hereinbefore described, the pipe first has one third of its length cut off and then the remaining two-thirds of the length is cut in half.

There is shown in FIG. 8 a dividing timer circuit employed when the material to be cut advances at a variable speed and it is required to divide the material into predetermined fractional lengths. The variable speed timing circuit operates generally in accordance with the same principles as the constant speed timing devices hereinbefore described, but additionally has features which compensate for the variable speed of the moving material such as the pipe or the like. The circuit shown in FIG. 8 is intended to time the cutting of a pipe or the like into equal halves and cooperates with S and D switches positioned as shown in FIGS. 3 and 4.

The variable speed timer circuit derives its input power from an alternating current power supply connected to the primary winding 302 of the transformer generally indicated at 300. The secondary winding 304 of the transformer 300 is connected to a voltage doubling circuit including capacitors 306 and 308 and diode rectifiers 310 and 312. The D.C. output of the voltage doubling circuit is applied to a voltage regulator generally indicated at 314 formed by a plurality of series-connected neon bulbs. The constant D.C. voltage output of the voltage regulator 314 is connected in series with load resistance 315 across the anode 317 and cathode 318 of a thyratron tube generally indicated at 316. Tube 316 also includes a control grid 319. Connected in shunt relation to the anode-cathode circuit of thyratron tube 316 and in series with diode rectifier 324 and choke coil 328 are two series-connected capacitors 320 and 322 of equal capacitance value. The output end of the two series-connected capacitors 320 and 322 at the junction 327 with diode rectifiers 324 is connected through diode rectifiers 323 to timing capacitor 325.

The S' contact, operated by the S switch through the S relay is connected in parallel shunt relation with capacitor 325 in the same manner as described in the previous circuits, the S' contact normally being closed to shunt out capacitor 325 to prevent charging thereof when the pipe to be cut is not in proximity to the S switch, and being actuated to open position to permit charging of the capacitor 325 when the pipe is in proximity to the S switch.

The variable speed timing circuit of FIG. 8 also includes a second thyratron tube generally indicated at 328, including an anode 330, a cathode 332, and a control grid 334. One end of timing capacitor 325 is connected to control grid 334 through a neon bulb 336 which functions in the same manner as described in connection with the circuit diagram of FIG. 5 to trigger the firing of the thyratron tube. The opposite end of capacitor 325 is connected to cathode 332 through a variable resistor 338. The voltage supply for anode 330 and the biasing voltage supply circuit for grid 334 are all substantially as described in the embodiment of FIG. 5 and will not be described again.

In accordance with the principle of operation of the circuit of the variable speed timer of FIG. 8, the regulated constant D.C. voltage across the output of the voltage regulator tubes 314 is pulsed by thyratron tube 316 through the capacitors 320 and 322, and the pulses are accumulated or added up on the capacitor 325 because of the blocking action of silicon diode rectifiers 323 and 324 which are poled in such manner as to permit discharge of capacitor 325 only through neon bulb 336 and thyratron tube 328 when neon bulb 336 and tube 328 fire. Diode rectifiers 323 are connected in series between the output end 327 of the series-connected capacitors 320 and 322 and the terminal 329 of timing capacitor 325.

An auxiliary circuit generally indicated at 340 in FIG. 8 is provided to vary the number of pulses supplied by thyratron tube 316 in proportion to the linear speed of the material being divided. This auxiliary circuit will now be described. The auxiliary circuit derives its power from a secondary winding 342 on input power supply transformer 300. Secondary winding 342 supplies power through a transformer 344 to a voltage doubling circuit including condensers 346 and 348 and silicon diodes 350 and 352. The output voltage from the voltage doubling circuit is fed through a limiting resistor 353 to a voltage regulator including a plurality of series-connected Zener diodes 354. The constant regulated D.C. voltage supplied by Zener diodes 354 is connected across a potentiometer 356. A capacitor 358 has one of its ends connected through resistors 364 and 365 to an adjustable tap on potentiometer 356, the opposite end of capacitor 358 being connected across the opposite end of the potentiometer. A neon bulb 370 is connected in series with the primary winding 372 of a transformer whose secondary winding 374 is connected in the input circuit of control grid 319 of thyratron tube 318. The voltage across neon bulb 370 which is derived from the input voltage supply is adjusted principally by the adjustable tap of potentiometer 356 to provide a voltage across neon bulb 370 just below its firing voltage. A small additional voltage is connected across the input to neon bulb 360, preferably across the resistances 364–365, this additional voltage being derived from a pulse generator source having a pulse frequency which is indicative of the linear speed of the moving pipe or rod. For example, a tachometer generator may be attached to any one of the roll members 18, 20, 22 on which the pipe moves past the cutter, the tachometer generator being driven at a speed which is proportional to the rate of movement of the conveyor rolls and hence of the rate of movement of the pipe to be cut. The tachometer generator has a voltage characteristic such that once in each cycle of its output voltage, a voltage peak is reached which is sufficient to cause firing of neon bulb 370. Each discharge of capacitor 358 through neon bulb 370 provides a pulse of current through the primary winding 372 which is transferred to the secondary winding 374 in the input circuit of control grid 319 of thyratron tube 316. The frequency of these pulses is a function of the rate of rotation of the tachometer generator and hence of the linear speed of the pipe or the like moving along the roll conveyor.

Each voltage pulse on secondary winding 374 reaches control grid 319 of tube 316 through capacitor 366 which is in series with secondary winding 374 in the input circuit to grid 319. This voltage pulse causes tube 316 to fire, connecting the regulated D.C. voltage supply across load resistor 315 and causing a discharge of capacitors 320 and 322 between the anode and cathode of tube 316. Although tube 316 is a thyratron tube, the circuit constants are such that tube 316 does not continue to fire as a thyratron tube normally does because the current through it is too small to maintain ignition, but instead tube 316 instantly reverts back to open circuit condition once capacitors 320 and 322 have discharged therethrough. Tube 316 is maintained in open circuit condition by the bias voltage across resistor 368 until another pulse from secondary winding 374 causes tube 316 to fire again.

Each time that tube 316 reverts to its open circuit connection at the end of each pulse from secondary winding 374, it applies a voltage across the discharged capacitors 320 and 322 through diode rectifiers 324, causing capacitors 320 and 322 to recharge. Each time a pulse of charging current flows through diode rectifiers 324 and choke coil 328 to recharge capacitors 320 and 322, an additional increment of charge is applied to capacitor 325. Thus, capacitor 325 stores a quantity of equal charges thereon, the quantity being equal to the number of pulses from the tachometer generator or other pulse generator, which, in turn, is a function of the speed of the moving material.

When the voltage on capacitor 325 reaches a predetermined value due to the accumulation of incremental charges thereon as just explained, the predetermined voltage value required also depending upon the voltage drop across resistors 338 and 339 as described in connection with the embodiment of FIG. 5, neon bulb 336 in series with the input to control grid 334 of the thyratron tube 329 will fire. The firing of neon bulb 336 applies a pulse to the control grid of tube 328 which causes thyratron tube 328 to fire to actuate the output relay in the anode circuit of tube 328 to control the clamping and cutting operations in the same manner as previously described in connection with the other embodiments of the invention.

With the S and D switches positioned in the same relative positions as in the diagrams of FIGS. 3 and 4, corresponding to a cutting of the pipe into two equal lengths, the S switch will be actuated to open the S' contact through the S relay when the leading end of the pipe to be cut passes adjacent the S switch. The S' contact will remain open as long as the pipe is passing adjacent the S switch. Opening of the S' contact permits capacitor 325 to become charged, as explained in connection with the previous embodiments, although in the circuit of FIG. 8, the capacitor 325 is not charged through limiting resistors as in the previous embodiments, but rather is charge by a succession of equal incremental pulses as previously explained.

When the pipe to be cut projects rearwardly of the D switch, as shown in FIG. 4, the D switch is actuated to open contact D' through the D relay, to cause both capacitors 320 and 322 to be connected in series. With both capacitors 320 and 322 connected in series with each other, the total capacitance of the two series-connected capacitors in one-half what it would be with only one of these two identical capacitors in the circuit, with the result that the recharging pulses to capacitors **320–322** are each only half as large as they would be if only capacitor **320** were in the circuit. Hence, the rate of charging of capacitor **325**, which is controlled by the recharging pulses to capacitors **320–322**, is only one-half what it would be if only capacitor **320** were in circuit.

When the pipe passes the D switch, the D' contact is closed by the D relay to bypass capacitor **322**, with the result that only capacitor **320** is in circuit. This causes the charging rate of capacitor **325** to double as compared to the rate when both capacitors **320** and **322** were in circuit, causing timing capacitor **325** to charge up to a predetermined voltage twice as fast as previously.

Thus, the action of the D' contact and its bypassing relation to capacitor **322** to permit doubling the charging rate to capacitor **325** when capacitor **322** is shunted by the D' contact provides the same type of timing action to cause the cut to the made exactly at the midpoint of the pipe, as that described in connection with the constant speed timing circuits of FIGS. 2 and 5, in which resistors were used instead of capacitors to control the charging rate on the timing capacitor which accumulates charges to trigger the firing of the thyratron tube. The variable speed timing circuit of FIG. 8 additionally compensates for the variable rate of speed of the moving material by controlling the frequency of the pulses to capacitors **320** and **322** and hence determines the rate of increase of the charge on the timing capacitor **325**.

The timing circuit shown in FIG. 8 is very flexible in its operation and the variable capacitors **320–322** may be adjusted so that the total number of pulses required to raise timing capacitor **325** to the trigger voltage may vary over a wide range, as, for example, from one pulse to several thousand pulses. The unit is capable of responding to an input pulse rate from a pulse source over a wide range of frequncies, such as the range of four pulses per minute to 100 pulses per second. The pulses received by the timing circuit may be of any wave form or shape from a wave shape having a smooth slow rise and fall to a sharp spiked pulse with a duration as short as one millisecond or less. In an operational embodiment, the pulses feed into an impedance of 50K ohms and can be of any voltage from a minimum of 2 volts to a maximum of 100 volts without series resistance being added. Resistance of the order of 10K ohms per volt for the lowest pulse voltage expected may be added in series with the pulse source and will not change the counting accuracy but will relieve the internal pulse circuit of unnecessary strain.

Since the pulses feeding the timing circuit of FIG. 8 may be of a wide variety of voltages and wave shapes without causing an error in the count, almost any type of pulse generator may be used, including the simple A.C. tachometer generator previously referred to. The pulse source may also include pulses or light or radiation from a hot moving object which could be picked up by a variable resistance device such as a phtototube or a silicon photodiode to supply pulses indicative of the rate of movement of the moving material.

The variable speed timer can measure accurately for cutting a pipe of known or unknown length traveling at a varying speed, even a pipe which is stopping and restarting.

By adjusting the capacitance value of the adjustable capacitor **322** relative to capacitor **320**, the change in pulse value when contact D' is closed compared to the pulse value when it is open may be used to adjust the apparatus for different fractional cuts, as, for example, the one-third cut described in the embodiment of FIGS. 6 and 7. This modification would also involve a placement of the S and D switches in positions similar to those shown in FIG. 7.

Any of the timing devices hereinbefore described may

be used to cut a predetermined fixed length of pipe rather than a predetermined fractional length of pipe. This may be done by eliminating or disconnecting the D switch and the contacts controlled thereby and using only the S switch which is first actuated by movement adjacent thereto of the leading end of the pipe. In such case, the circuit constants, whether they be the resistor sections of FIGS. 2, 5, and 6, or the capacitors of the variable speed embodiment of FIG. 8, are so adjusted with respect to the timing capacitor and are so correlated with respect to the speed of movement of the pipe and the characteristics of the thyratron tube, as to cause the thyratron tube to fire when a predetermined fixed length of pipe has passed by the S switch and by the cutter.

In any of the various embodiments described for cutting predetermined fractional lengths, such as cutting a pipe into two equal lengths or three equal lengths, the timing and control circuit will always operate in such manner as to cut at least one usable fractional length out of a given length of pipe, even though the total pipe length before cutting is insufficient to cut into the total number of fractional parts. Thus, for example, in the embodiment of FIGS. 2–5, in which the pipe is cut into two equal lengths, assume that a pipe moves along the conveyor rolls toward the pipe cutter which is too short in its total length to be cut into two minimum 50-foot lengths. Thus, assume that a pipe 80 feet long moves along the conveyor rolls where the minimum length before cutting for which the S and D switches are set is 100 feet. It will be clear from the previous description given that the movement of the pipe past the S switch will start the timing circuit in operation in such manner as to cause a cut to be made at the end of 50 feet of movement of the 80-foot pipe, leaving a piece remaining which is 30 feet in length. This is an improvement over prior art apparatus in which pipe having a length before cutting less than the required minimum length is sometimes cut into two equal lengths, each of which is shorter than the required minimum length after cutting.

Similarly, in the case of the embodiment of FIGS. 6 and 7, where the timing device functions to cut a pipe length into three equal lengths, assume that a pipe having a length of less 100 feet moves toward the cutter. It will be clear from the description previously given that the timing and control system of FIGS. 6 and 7 will operate first to cut a piece equal to the minimum one-third fractional length, namely, a section 33⅓ feet in length, during the first of the two separate measuring and cutting operations previously described in connection with the embodiment of FIGS. 5 and 6. The timing circuit will then switch over to its connections for the second step, in which the length of the pipe remaining after the first one-third cut has been made is cut, to provide a second minimum one-third fractional length, if the pipe is sufficiently long to permit two such cuts to be made. Thus, out of the total length of pipe, at least one, and possibly two, useful one-third length sections will be provided, depending upon the length of the pipe.

Reference is now made to FIGS. 9–12 which relate to the apparatus and timing circuitry used to crop predetermined lengths from the forward ends of longitudinally moving material to eliminate off-gauge, rough, or irregular ends.

As seen in FIG. 9, which shows schematically the orientation of the sensing switches used in connection with the cropping operation, a pair of switches A and B are spaced apart from each other along the path of movement of the pipe or the like which is to be cropped. Switch A is positioned to be reached first by the forward end of the moving material, and switch B is positioned following switch A so as to be reached later by the forward end of the moving member. A cutting member C is positioned beyond switch B along the path of the moving material. The switches A and B may be displaced any predetermined distance from each other along the path of movement of the moving material, and in the illustrated embodiment it is assumed that they are displaced ten feet from each other. Similarly, the cutter C may be displaced any predetermined distance beyond the switch B, and in the illustrated embodiment it is assumed that cutter C is displaced ten feet beyond switch B. The A and B switches are preferably switches of the proximity type which do not require actual contact with the moving material. Proximity switches are well known in the art and may operate either on the inductive or capacitive principle. The A sensing switch when actuated to closed position by the presence of the forwardly moving material energizes the operating coil of the A relay to actuate normally open contact A–1 to closed position and to actuate normally closed contact A–2 to open position, as will be further explained hereinafter. The B sensing switch when actuated to closed position by the presence of the forwardly moving material energizes the operating coil of the B relay to actuate normally open contacts B–1, B–3, and B–4 to closed position and to actuate normally closed contact B–2 to open position, as will be further explained hereinafter.

Referring now to FIG. 10, the timing circuit for the cropping operation derives its input power from an alternating current supply connected to the primary winding **402** of a transformer generally indicated at **400**. The secondary winding **404** of transformer **400** is connected to a voltage doubling circuit including capacitors **406** and **408** and diode rectifiers **410** and **412**. The voltage doubling circuit also includes resistors **414** and **416**. The D.C. output of the voltage doubling circuit is applied to a voltage regulator generally indicated at **418**, formed by a plurality of series-connected neon tubes.

The timing circuit includes a storage capacitor **420** having a terminal **422** which is directly connected by conductor **424** to the midpoint **426** of the bank of neon tubes which form voltage regulator **418**. The opposite terminal **428** of capacitor **420** is connected to the negative terminal of the voltage regulator **418** in series with resistor **430**, normally open contact A–1 operated by the A relay through the A switch, and in series with the normally closed contact B–2 operated by the B relay through actuation of the B sensing switch. Terminal **428** of capacitor **420** is also connected to the positive side of the voltage regulator **418** in series with fixed resistor **436** and variable resistor **438**, and in series with normally open contact B–1 which is operated to closed position by energization of the B relay through closure of the B sensing switch.

The A relay, when energized, also opens normally closed contact A–2 which is connected in parallel shunting relation with storage capacitor **420** so that when contact A–2 is closed capacitor **420** does not charge, but when contact A–2 is open capacitor **420** is permitted to charge.

The timing circuit of FIG. 10 also includes a thyratron gaseous discharge tube generally indicated at **450**, having an anode **452**, a cathode **454**, a control grid **456**, and a screen grid **458** which is grounded to cathode **454**.

The anode **452** of tube **450** derives its D.C. voltage supply from a voltage doubler circuit supplied from secondary winding **474** of a transformer generally indicated at **470**, whose primary winding **472** is connected to secondary winding **476** of transformer **400**. The voltage doubler circuit includes capacitors **478** and **480** and diode rectifiers **482** and **484**. The output of the voltage doubler circuit is applied in series with a resistor **486** across a pair of series-connected Zener diodes **488** and **490** which maintain a stable regulated D.C. voltage output. Anode **452** and cathode **454** are connected across Zener diode **490** to maintain a stable anode supply voltage. Control grid **456** is supplied with a negative bias by the adjustable resistor **492** connected across Zener diode **488**, resistor **492** including an adjusting tap **494** connected to control grid **456** in series with capacitor **420**.

An output relay generally indicated at **460** is connected in the circuit of anode **452**, relay **460** including an operating coil **462** which, when energized, controls the closure of contacts **464** and **466** which are respectively in the cutter and clamping circuits used to cut and clamp the moving workpiece as in the previous embodiments of the invention.

The timing circuit also includes a reset relay RR having an operating coil which is energized when contact **468** is closed by the operation of output relay **460** which will be explained more fully hereinafter. When reset relay RR is energized, it opens normally closed contact R–1 in series with the anode circuit of tube **450**. Opening of contact R–1 disconnects the voltage supply from anode **452** thereby to extinguish the tube and give control back to control grid **456**, as is well known in connection with thyratron gas tubes.

In order to insure against firing of the tube **450** during further movement of the member which has just been cropped, a holding circuit is provided to keep reset relay RR energized until the trailing end of the moving pipe or the like has passed the B switch. The holding circuit includes a contact R–2, which is closed upon energization of relay RR, in series with normally open contact B–4. Contact B–4 is further in series with contact R–2 and is closed by actuation of the B relay due to the passage of the moving material past the B switch. Contact B–4 is necessarily already closed at the time reset relay RR is energized by the momentary closing of contact **468** when the timer's output relay **460** operates to give control to crop out, so the relay holding circuit is completed and does not reopen until the trailing end of the pipe has moved past the B switch. Thus, it is impossible for another cutting operation to occur on the moving pipe after the cropping out has been made.

Operation of timing circuit of FIG. 10

It will be assumed that the sensing switches A and B are positioned ten feet from each other along the path of movement of the moving material, and that the cutter C is positioned ten feet beyond switch B, all as shown in FIG. 9. Assume also that it is desired to crop a length of 2.5 feet from the forward end of each piece of moving material which moves past the sensing switches A and B and the cutter C.

It is also assumed that thyratron gas tube **450** has a characteristic such that at the given supply voltage on anode **452**, tube **450** will not fire when the bias on control grid **456** is more negative than a trigger voltage of −2.5 volts. The adjustable tap **494** on bias resistor **492** is adjusted to maintain a grid bias voltage just equal to the trigger voltage.

With the placement of the sensing switches and cutter as shown in the diagram of FIG. 9, the charging period of the capacitor **420** is during the interval in which the forward end of the moving material moves from sensing switch A to sensing switch B, a distance of ten feet, while the discharging period of the capacitor is the time interval required for the forward end of the advancing material to move from sensing switch B to cutter C, a distance of ten feet, *plus* the desired length of crop, which, in the assumed example, is 2.5 feet. Thus, in the example, the interval for discharge of capacitor **220** is the time interval required for the forward end of the advancing material to move a total distance of 12.5 feet. Therefore, the ratio of the charging interval to the discharging interval is 0.8, and the ratio of the rate of discharge to the rate of charge must be 0.8 for the total discharge to quantitatively equal the total charge over the longer interval of the discharge. The constant of the timing circuit for the desired length of crop is 0.8 for the given placement of the sensing switches and cutter.

The tap on the adjustable resistor **438** in the discharge circuit for capacitor **420** is adjusted to give combined resistors **436** and **438** a value relative to the resistor **430** in the charging circuit to give the desired constant of 0.8 just mentioned.

When the forward end of the material which is to be cropped reaches the A switch, the A switch closes to energize the A relay. Energization of the operating coil of the A relay opens the normally closed shunting A–2 to permit capacitor **420** to charge. Energization of the A relay also closes the normally open contact A–1 to connect terminal **428** of capacitor **420** to the negative terminal of voltage regulator **418**, in series with resistor **430**, in series with contact A–1, and in series with normally closed contact B–2 controlled by the B relay.

Terminal **428** of capacitor **420** continues to be connected to the negative terminal of voltage regulator **418** as just described during the interval required for the forward end of the advancing material to pass through the space from sensing switch A to sensing switch B, a distance of ten feet in the illustrated embodiment of FIG. 9. During this interval, capacitor **420** becomes progressively more negatively charged, as indicated, for example, by the graphs of FIGS. 10 and 11, which illustrate charging and discharging with different constants for the timing circuit than in this example but indicate the principle involved. The negative charge of capacitor **420** adds to the negative bias of approximately —2.5 volts established by the biasing resistor **492** to maintain control grid **456** of thyratron tube **450** at a negative value such that tube **450** cannot fire. Furthermore, during the charging interval when only relay A is closed, contact B–3 in the anode circuit of tube **450** and controlled by the B relay is in its normally open position, so that tube **450** cannot fire during the interval in which the forward end of the advancing material moves from sensing switch A to sensing switch B.

When the forward end of the advancing material reaches sensing switch B, the B switch is closed to energize the operating coil of the B relay, to close the normally open contact B–1 in the discharge circuit for the capacitor and to open the normally closed contact B–2 in the charging circuit for capacitor **420**. Thus, terminal **428** of capacitor **420** is connected through closed contact B–1 and resistor sections **436** and **438** to the positive terminal of voltage regulator **418**, so that capacitor **420** begins to discharge, the discharge rate in the assumed example being 0.8 of the charging rate as determined by the adjustment of variable resistor **438**. Closure of the B switch and energization of the operating coil of relay B also is effective to close the normally open contact B–3 in the circuit of anode **452** of thyratron tube **450**. When capacitor **420** becomes completely discharged and reaches a zero voltage after a time interval determined by the timing circuit constant of 0.8, the negative potential on control grid **456** is then determined only by the negative bias established by bias resistor **492** which, as previously stated, is set to equal the trigger voltage of thyratron tube **450**. At this instant, tube **450** fires to energize output relay **460** in the output circuit of anode **452**. Energization of the operating coil **462** of relay **460** actuates contacts **464** and **466** in the cutter and clamp circuits to clamp the moving material and to actuate the cutter to make the cropping cut on the material which has been clamped in position.

Assume, in the foregoing example, that the material to be cropped passes from sensing switch A to sensing switch B in ten seconds, moving at a constant rate of one foot per second, and that the constant for the timing circuit has been set at 0.8 as just described. The material will travel for 12.5 seconds after reaching the B switch before the capacitor **420** completely discharges to zero voltage across the capacitor, leaving only the trigger voltage provided by bias resistor **492** on control grid **456**. At the constant rate of movement of one foot per second assumed in the example, the forward end of the moving material will project 2.5 feet beyond the cutter C at the time the thyratron tube **450** fires to actuate the clamping and cutting means, so that a length of 2.5 feet will be cropped from the forward end of the moving material.

With a given constant for the timing circuit, such as the constant 0.8 just described, the same length of material will be cropped from the forwardly moving end of the material regardless of the speed of the advancing material as long as the speed, whatever it may be, remains constant. Thus, for example, with the constant of the timer set at 0.8 as described in the previous example, assume that the speed of the moving material is increased so that only two seconds are required for the forward end of the material to move the ten foot distance from sensing switch A to sensing switch B. Thus, the capacitor **420** would be charged during an interval of two seconds. When the end of the material reaches sensing switch B and disconnects the charging circuit and connects the discharge circuit, a period of 2.5 seconds will elapse before the capacitor **420** discharges back to the zero voltage level at which the charging period began, at which the negative bias on negative grid **456** is only that provided by biasing resistor **492**, namely, the —2.5 volts equal to the trigger voltage of tube **450**. During this 2.5 second interval of the discharge of of capacitor **420**, the forward end of the moving material would have moved 12.5 feet beyond sensing switch B at its now assumed rate of 5 feet per second. This would place the forward end of the material 2.5 feet beyond the cutter C when the tube fires, and thus 2.5 feet would again be cropped from the forward end of the material, as in the preceding example, in which the material was assumed to be moving at only one foot per second. Thus, with a given constant setting of the timing circuit, the same length of cropping cut will be made regardless of the speed of movement of the material, as long as the speed of movement is constant.

Actuation of output relay **460** serves to close contacts **464**, **466** and **468**, thereby energizing the cutting, clamping, and reset relay RR circuits. A suitable holding circuit may be provided so that these circuits will remain energized throughout the complete holding and cutting operation. The holding circuit will necessarily be deenergized when the cutter is retracted to the initial or non-cutting position while the clamp is moved to the unclamped position. Suitable, means, such as a limit switch, may be provided to insure that when the clamp and cutter are deenergized they will be prepared for the next cutting cycle. Energization of reset relay RR opens contact R–1 in the circuit of anode **452** of thyratron tube **450** to interrupt thereby the firing of the tube and deactivate the tube until the next cycle of operation. The deenergization of tube **450** deenergizes operating coil **462** of the output relay and causes contacts **464** and **466** to move to deactivated positions. Since the operation of output relay **460** closes contact **468**, energizing reset relay RR, and reset relay contact R–1 opens to deenergize output relay **460**, output relay contacts **464** and **466** would stay closed for a very short period of time. A series connected capacitor **520** and resistor **522** are connected in shunt with series connected contacts B–3 and R–1. When reset relay contact R–1 opens to deenergize output relay **460**, the charging current taken by capacitor **520** will be sufficient to keep output relay **460** energized for the necessary length of time sufficient to hold output relay contacts **464** and **466** closed long enough to start the cutting and clamping cycle. As hereinbefore pointed out, each of the clamping and cutting circuits is provided with a suitable holding circuit to insure the clamping and cutting cycle is completed before deenergization occurs.

The reset relay RR remains energized to hold contact R–1 in the circuit of anode **452** open until the trailing end of the moving material has moved past the B switch, thereby to insure that no additional cuts are made after the cropping cut. This is accomplished by the holding circuit for relay RR, including the contact R–2 closed by relay RR, and contact B–4 which is held closed by the B relay as long as the B relay is energized by the passage of the workpiece past the B switch. A voltage build-up at the grid **456** of the thyratron **450** is prevented by the energization of reset relay RR which closes contact R–3 in shunting relationship to capacitor **420**.

During the passage of the remaining portion of the member which has just been cropped, both the A and B switches remain closed due to the proximity of the passing material, and the A and B relays remain energized as long as the material continues to pass by the A and B switches.

As soon as the trailing end of the material has passed the A switch, the A switch opens to deenergize the A relay thereby to reclose normally closed contact A–2 of the A relay which shunts capacitor **420**. As soon as the trailing end of the material passes the B switch, the B switch opens to deenergize the operating coil of the B relay, thereby to open normally open contact B–1 in the discharge circuit and to permit normally closed contact B–2 in the charging circuit to reclose. Also, deenergization of the B relay opens normally open contact B–3 in the output circuit of anode **452** of tube **450** and opens normally open contact B–4 in the holding circuit for reset relay RR thereby to deenergize the operating coil of the reset relay and permit normally closed reset contact R–1 in the circuit of anode **452** to reclose. Normally open contact R–3, which is closed shunting capacitor **420**, is opened when the reset relay RR is deenergized. Thus, when the end of the passing material has moved past the A and B switches, the circuit is restored to the condition in which it is ready to crop the next piece of moving material which approaches the A and B switches.

It can be seen from the foregoing that there is provided, in accordance with this invention, an electronic timing and cutting apparatus and method which have great utility, particularly in connection with cutting of moving material, such as pipes, rods, extrusions, and the like into predetermined fractional lengths or into predetermined fixed lengths, or for cropping predetermined lengths from the ends of moving material.

The apparatus of the invention does not require a high initial investment, as in the case of most prior art apparatus for the same purpose, and presents very little in the way of maintenance problems. The apparatus can be used for either cutting moving material into predetermined fractional lengths or into repeating fixed lengths, as required. The timing and control apparatus are efficient and uncomplicated in their operation and permit the use of relatively simple controls for adjusting the apparatus for varying operating conditions. The timing and cutting apparatus also insures that when the moving material is less than the minimum length required to provide a plurality of cuts of minimum length, the material will be cut in such manner as to provide one or more usable fractional lengths, rather than a plurality of fractional lengths, none of which is equal to the minimum length required. Also, the timing and control apparatus illustrated in connection with FIGS. 9–12 provides a very effective and efficient means for cropping predetermined lengths from the ends of pipes, rods, extrusions and the like, where it is necessary to make cropping cuts on such members.

While there have been shown and described particular embodiments of the invention, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention and, therefore, it is aimed to cover all such changes and modifications as fall within the true spirit and scope of the invention.

I claim:

1. A timing circuit to control the cropping of predetermined variable lengths from the end of a longitudinal member moving along a transport path, comprising: a first sensing means positioned along a transport path and generating an output signal in response to the leading end of said moving material passing thereby, a second sensing means positioned along the transport path posteriorly of the first sensing means with respect to the direction of material travel and generating a signal in response to the leading end of said moving material passing thereby, a gaseous discharge device biased in a normal cut-off condition and having input and output circuits, a timing condenser operatively connected to said input circuit of said gaseous discharge device for control thereof, a timing condenser charging path including normally open contacts controlled by said first sensing means and normally closed contacts controlled by said second sensing means, said timing condenser charging path accordingly being operative to charge said timing condenser upon the leading end of an item passing by said first sensing means, a condenser discharge path including a normally open contact controlled by said second sensing means, said condenser discharge path being operable to discharge said timing condenser to a triggering level for said gaseous discharge in response to the leading end of an item passing by said second sensing means, said condenser discharge path having a differentially variable amount of impedance therein to enable the triggering of said gaseous discharge device upon said moving material assuming a predetermined position in said transport path, material clamping means operatively positioned along the path of material travel and responsive to energization of said gaseous discharge device to restrain said material and prevent further movement along said transport path, material cutting means operatively positioned along the material transport path such that upon energization of said gaseous discharge device the predetermined desired amount of leading end will have passed thereby, gaseous discharge device resetting means operative in response to energization of said cutter means to remove the operating potential therefrom, clamping and cutting hold circuit means insuring proper duration of said clamping and cutting operation after deenergization of said gaseous discharge device by said resetting means, said resetting means being operable for as long as said moving material is sensed by said second signal generating means.

2. For use with a material clamping and cutting apparatus which is controlled by a normally nonconducting gaseous discharge device which is responsive to a triggering voltage applied to the input circuit thereof for actuation of said material clamping and cutting operation, a timing circuit to control the cropping of predetermined variable lengths from the end of a longitudinal member moving along a transport path, comprising, a first sensing means positioned along a transport path and generating an output signal in response to the leading end of said moving material passing thereby, a second sensing means positioned along the transport path posteriorly of the first sensing means with respect to the direction of material travel and generating a signal in response to the leading end of said moving material passing thereby, a timing condenser operatively connected to the input circuit of the gaseous discharge device for control thereof, a timing condenser charging path including normally open contacts controlled by said first sensing means, said timing condenser charging path accordingly being operative to charge said timing condenser upon the leading end of an item passing by said first sensing means, a condenser discharge path including a normally open contact controlled by said second sensing means, said condenser discharge path being operable to discharge said timing condenser to the triggering level of the gaseous discharge tube in response to the leading end of an item passing by said second sensing means, said condenser discharge path having a differentially variable amount of impedance therein to enable the triggering of said gaseous discharge device upon said moving material assuming a predetermined position in said transport path relative to the cutting apparatus, deenergization means for the gaseous discharge device operative in response to energization of said cutter means to remove operating potential therefrom, clamping and cutting hold circuit means insuring proper duration of said clamping and cutting operation after deenergization of said gaseous discharge device.

3. A circuit for cropping predetermined variable amounts of leading ends from a longitudinal member moving along a transport path and thereafter preventing further cutting operations from occurring thereupon the combination comprising, a first sensing means positioned along a transport path and generating an output signal in response to the leading end of said moving member passing thereby, a second sensing means positioned along the transport path posteriorly of the first sensing means with respect to the direction of material travel and generating a signal in response to the leading end of said moving material passing thereby, a gaseous discharge device having input and output circuits, means operatively connected to the input circuit of said gaseous discharge device and biasing said gaseous discharge device in a normally cut-off condition, a timing condenser operatively connected to the input circuit of said gaseous discharge device for control thereof, a timing condenser charging path including first normally opened contacts controlled by said first sensing means and first normally closed contacts controlled by said second sensing means, said timing condenser charging path operative to charge said timing condenser to a predetermined gaseous discharge device cut-off level upon the leading end of said member assuming a position along said transport path between said first and second sensing means, a condenser discharge path including a second normally opened contact controlled by said second sensing means, said condenser discharge path operable to discharge said timing condenser to the triggering of said gaseous discharge device in response to the leading end of said member being sensed by said second sensing means, said condenser discharge path having a differentially variable amount of impedance therein settable to enable triggering of said gaseous discharge device upon said longitudinally moving member assuming a predetermined position in said transport path, member clamping means operatively positioned along the path of member travel restraining said member and preventing further movement along said transport path, member cropping means operatively positioned along said transport path posteriorly of said first and second sensing means, in the direction of member movement, such that upon energization of said gaseous discharge device a predetermined desired amount of leading end will have passed thereby, means connected in said output circuit of said gaseous discharge device for initiation of said clamping and cropping means in response to energization of said gaseous discharge device, gaseous discharge device resetting means including second normally closed relay contacts controlled thereby, operative in response to the occurrence of a cropping operation, said second normally closed relay contacts controlled by said resetting means operatively connected in series circuit with said clamping and cropping initiation means in said output circuit of said gaseous discharge device, such that upon energization of said gaseous discharge device said cutting and clamping means are operative, said gaseous discharge resetting means operative in response to performance of said cropping operation to open its associated second normally closed relay contacts connected in said output circuit of said gaseous discharge device to de-energize said gaseous discharge device, and a gaseous discharge device resetting means holding circuit including a third pair of normally opened relay contacts controlled by said second sensing means to prevent further energization of said gaseous discharge device for as long as said second sensing means is responsive to said member passing thereby along the transport path.

4. A combination as described in claim 3 including a clamping and cutting hold circuit means insuring proper duration of said clamping and cutting operation after de-energization of said gaseous discharge device by said resetting means.

5. A combination as described in claim 4 wherein said clamping and cutting hold circuit is connected in parallel with said second normally closed relay contacts controlled by said gaseous discharge device resetting means in said output circuit of said gaseous discharge device.

6. A combination as described in claim 5 wherein said clamping and cutting hold circuit includes a serially connected resistance and condenser timing circuit having a predetermined discharge rate to insure proper duration of the cutting and clamping operations after a de-energization of said gaseous discharge device occurs.

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