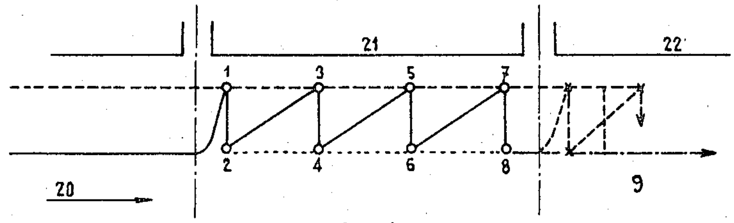
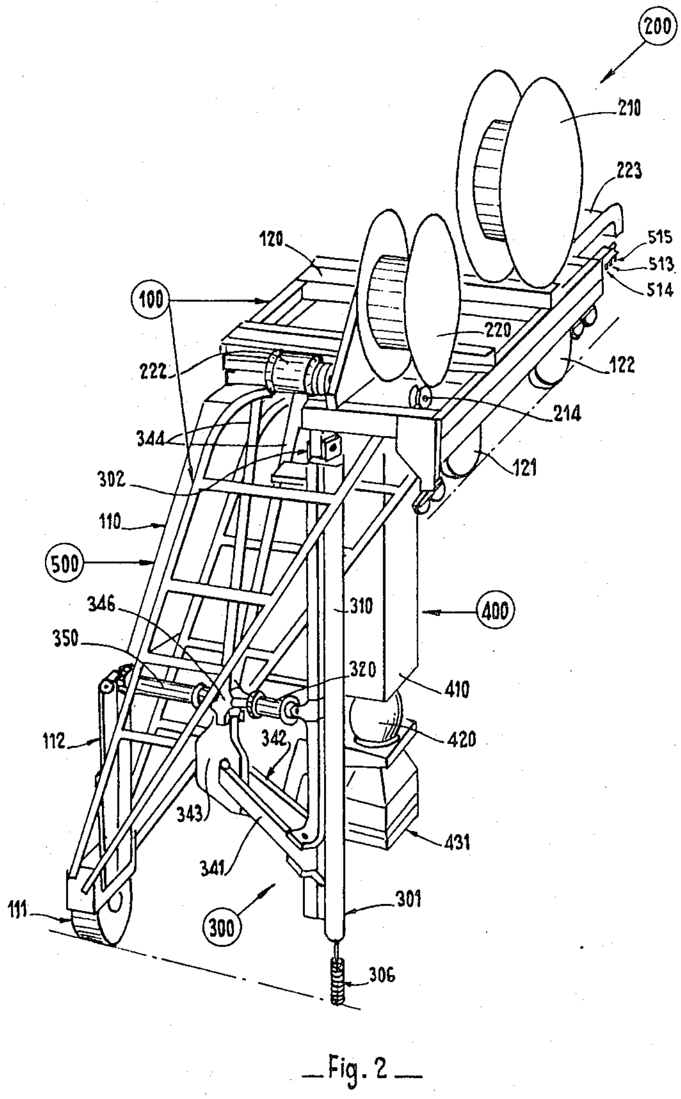
March 5, 1968 J. CHAMBRAN 3,372,106

MACHINE AND METHOD FOR CRUST PIERCING AND FEEDING OF MOLTEN ELECTROLYTIC BATHS

Filed Sept. 23, 1964 16 Sheets-Sheet 1



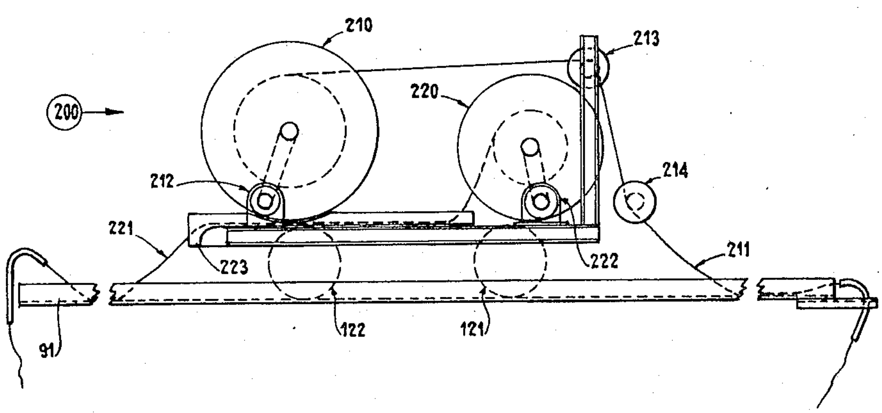
—Fig. 1—



—Fig. 2—

INVENTOR.
Jacques Chambran

BY
McDougall, Hersh & Scott
Att'ys



— Fig. 3 —

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MACHINE AND METHOD FOR CRUST PIERCING AND FEEDING OF MOLTEN ELECTROLYTIC BATHS

Filed Sept. 23, 1964 16 Sheets-Sheet 3

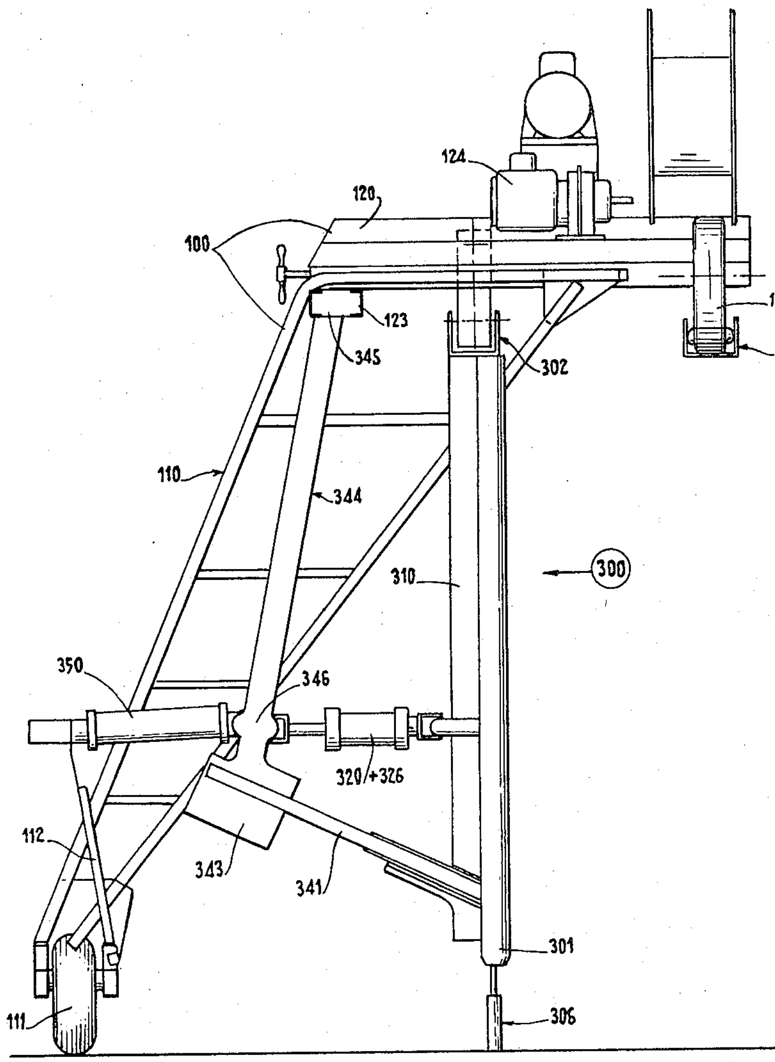
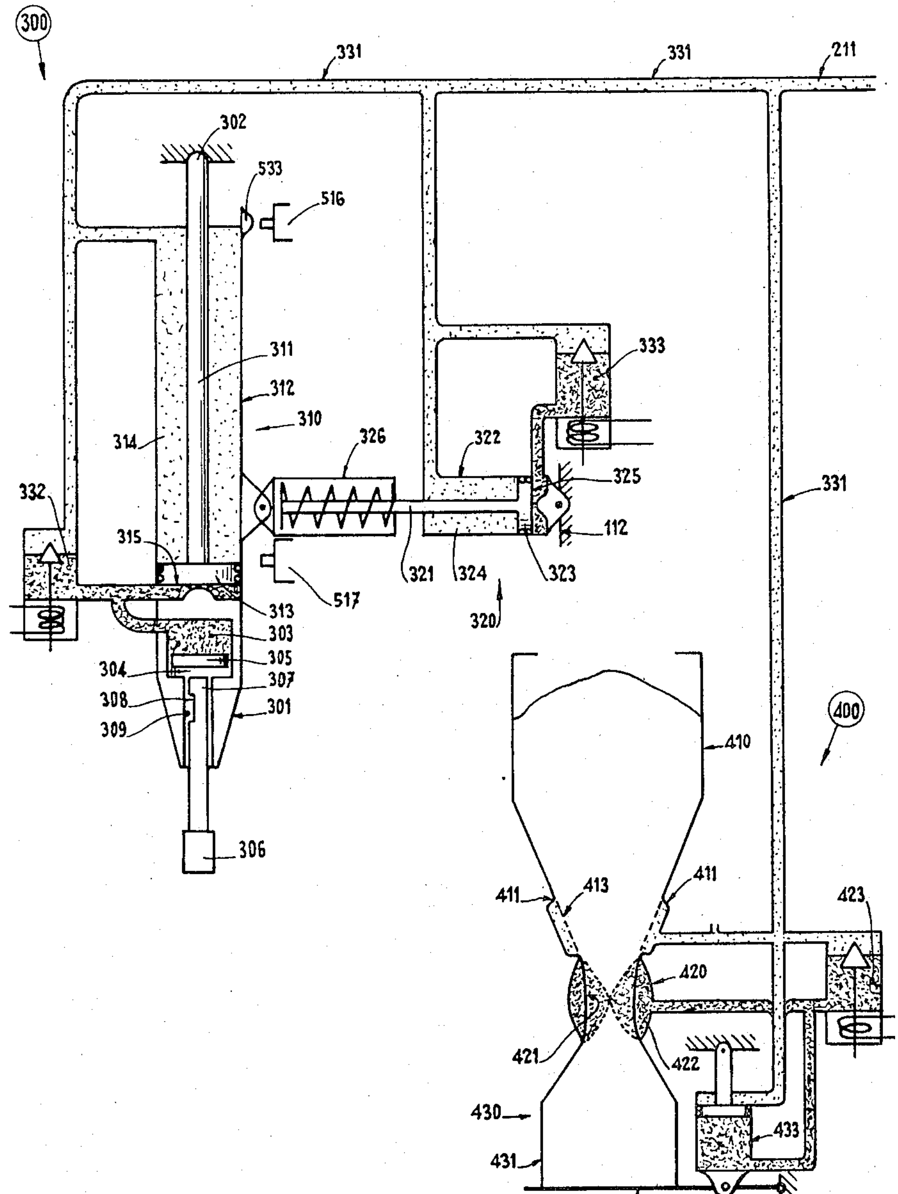


Fig. 4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302
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314
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322
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332
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517
320
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Fig. 5

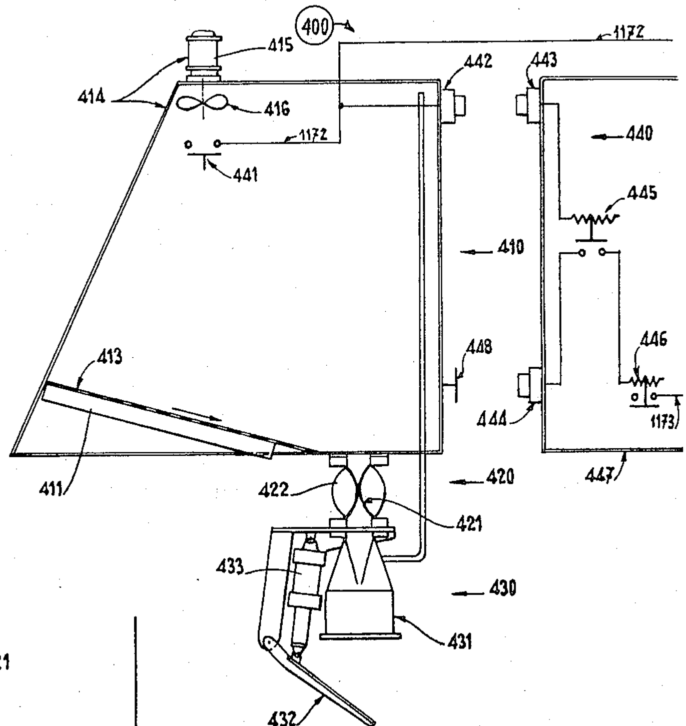


Fig. 6

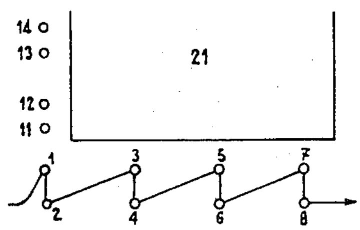


Fig. 8

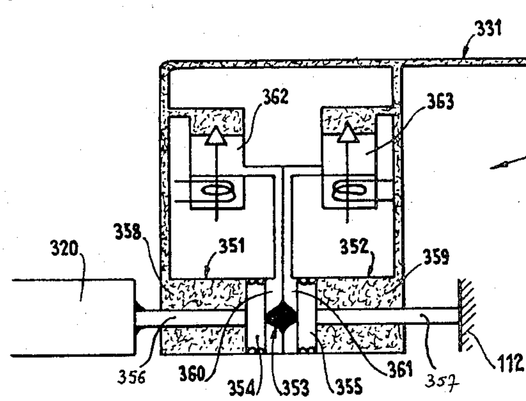
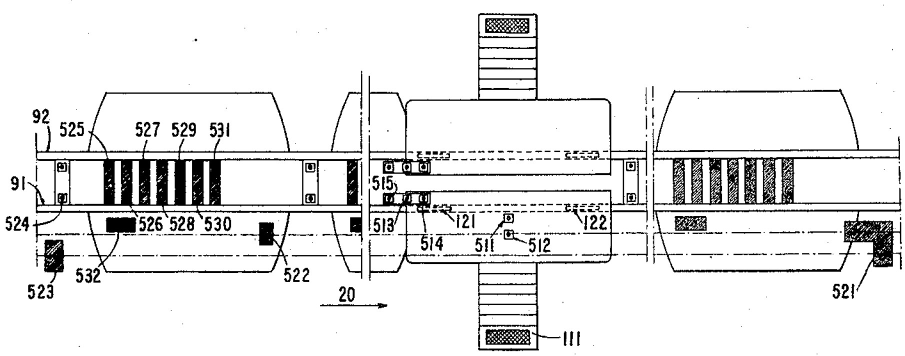


Fig. 7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525
527
529
531
91
524
526
528
530
532
523
522
515
513
514
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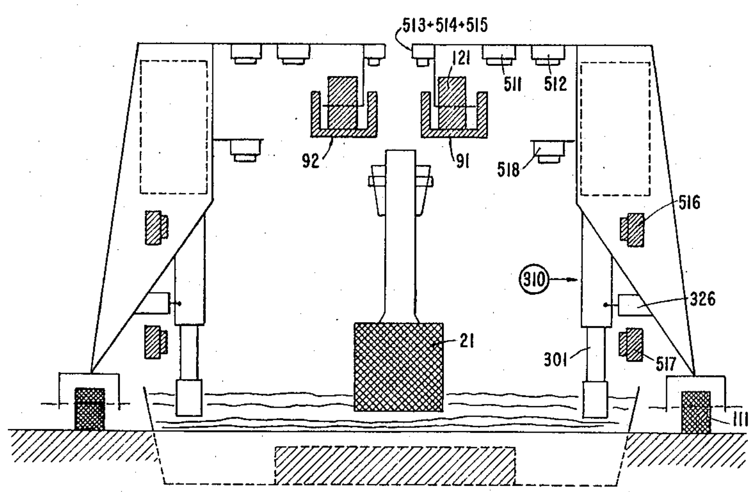
122
521
20
111

Fig. 9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517
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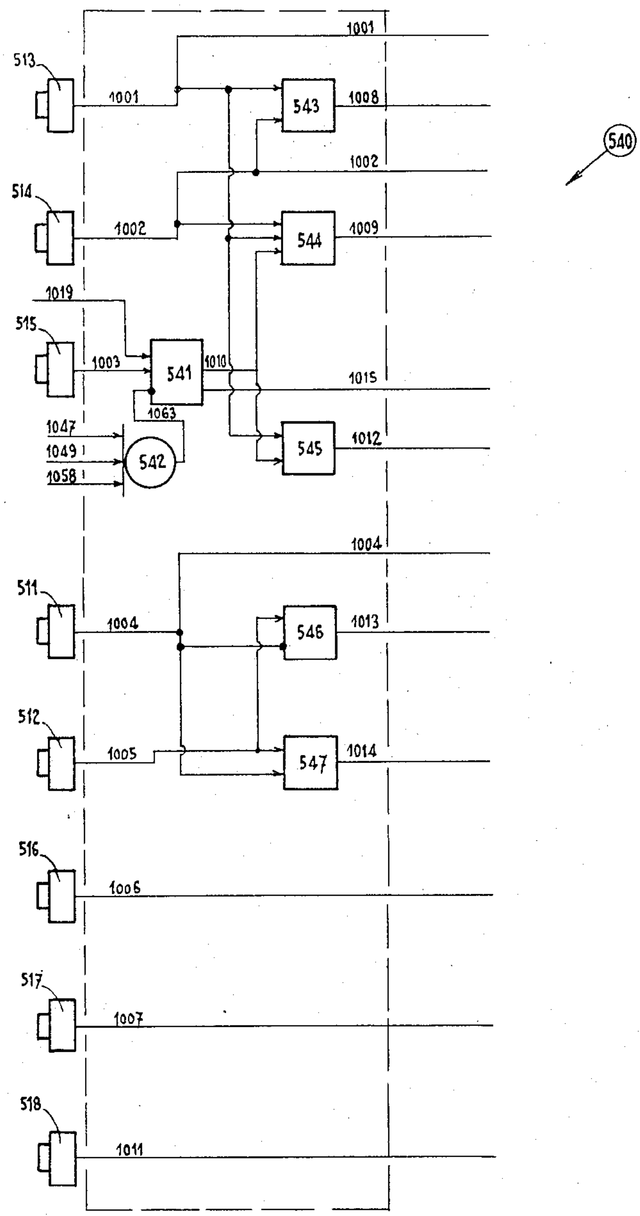
Fig. 10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1001
543
1008
514
1002
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1049
1058
542
545
1012
1004
511
1004
546
1013
512
1005
547
1014
516
1006
517
1007
518
1011

Fig. 11

MACHINE AND METHOD FOR CRUST PIERCING AND FEEDING
OF MOLTEN ELECTROLYTIC BATHS

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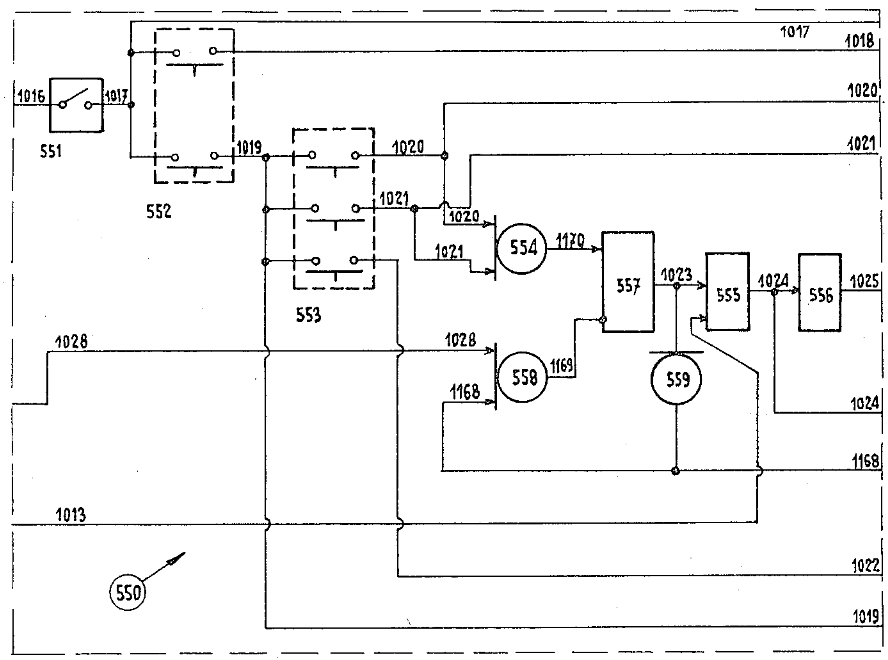
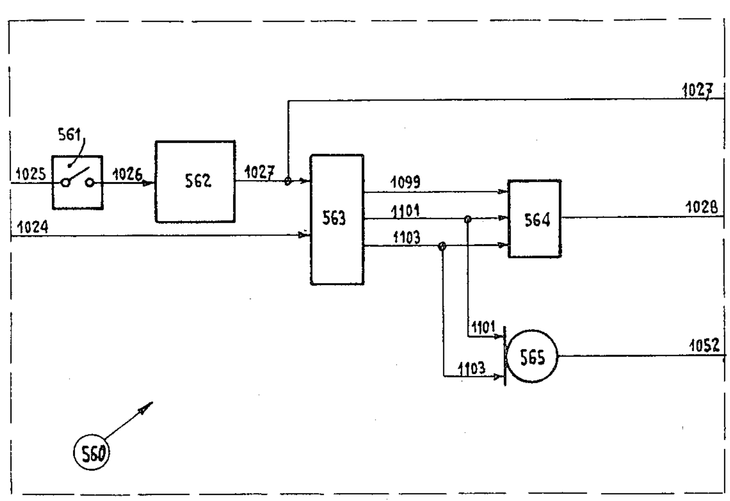
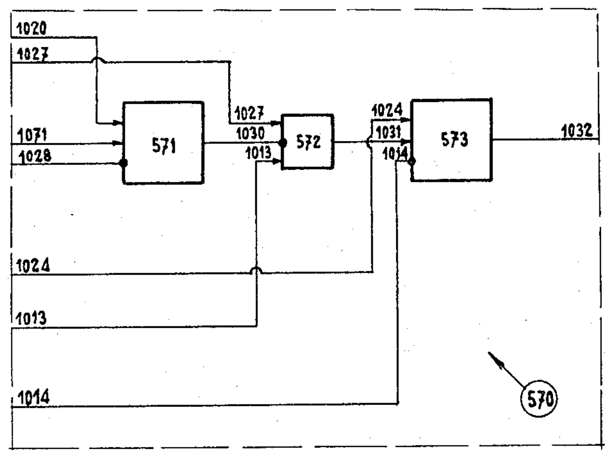


—Fig. 12—



—Fig. 13—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1071
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1013
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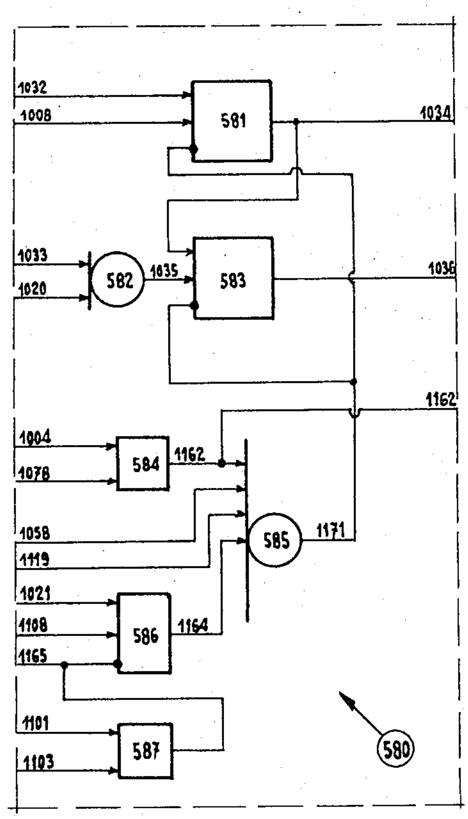
1014
570

— Fig. 14 —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1020
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1004
1078
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1162
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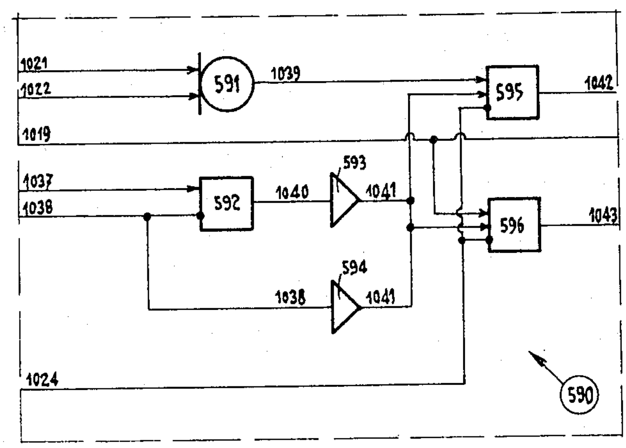
1119
585
1171
1021
1108
1165
586
1164
1101
1103
587
580

— Fig. 15 —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1022
591
1039
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1038
1041
1024
590

Fig. 16

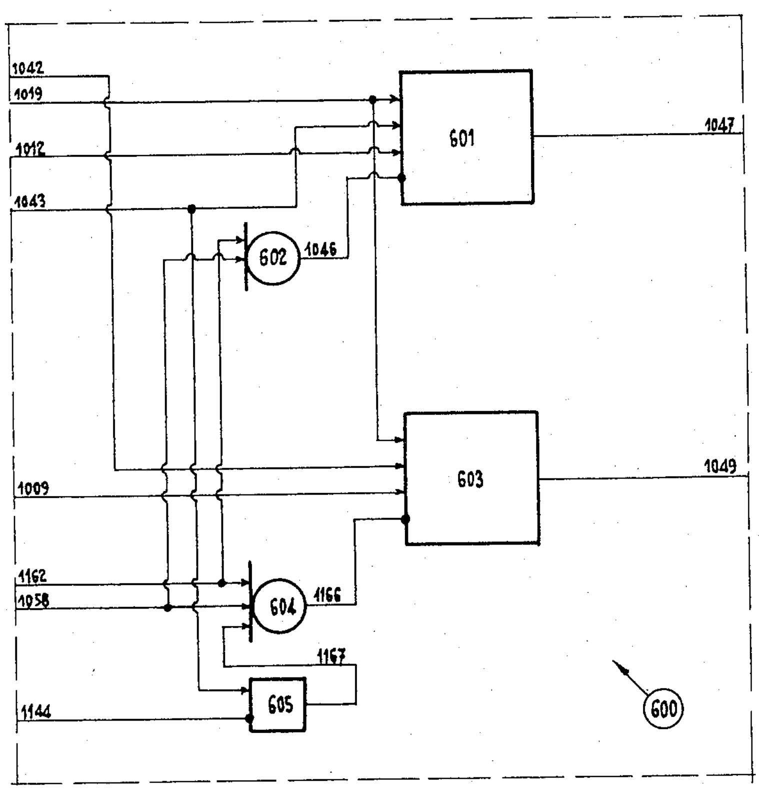
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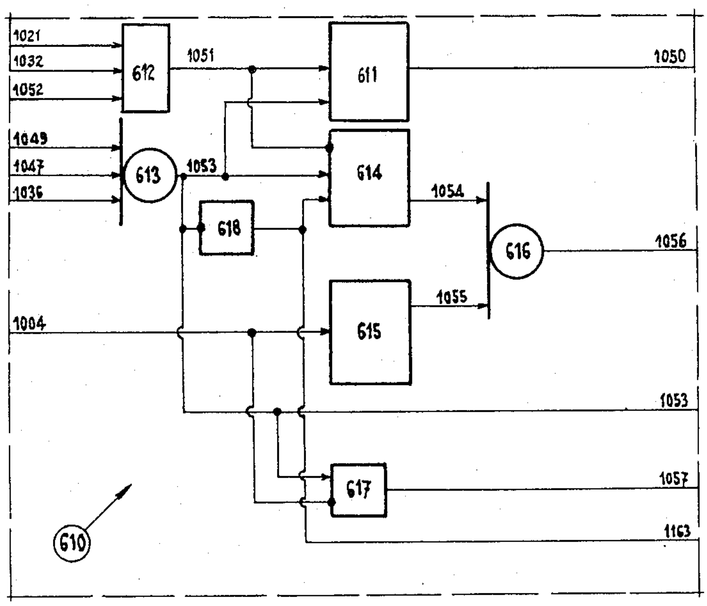
Fig. 17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612
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1056
1055
1004
615
1053
617
1057
1163
610

Fig. 18

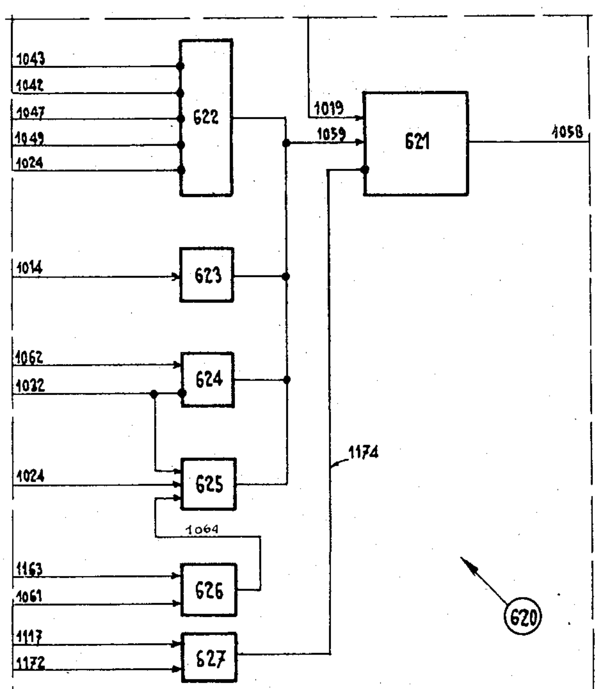
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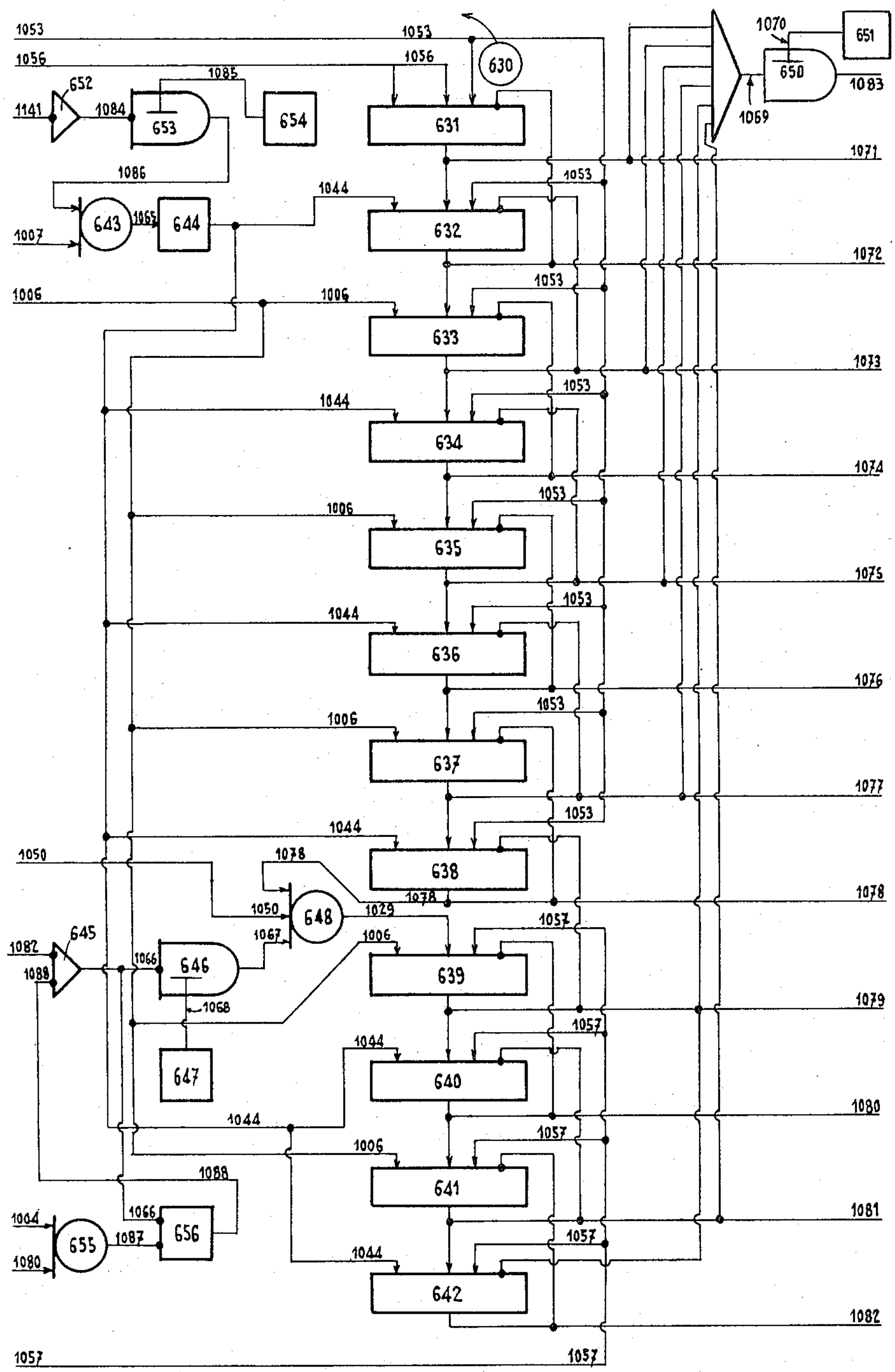
Fig. 19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645
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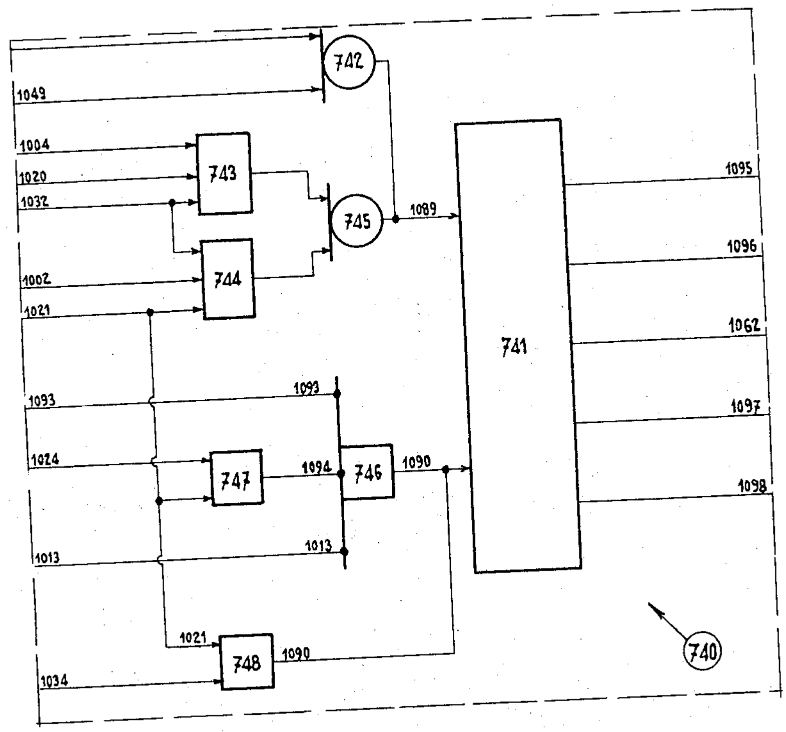
—Fig. 20—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1021
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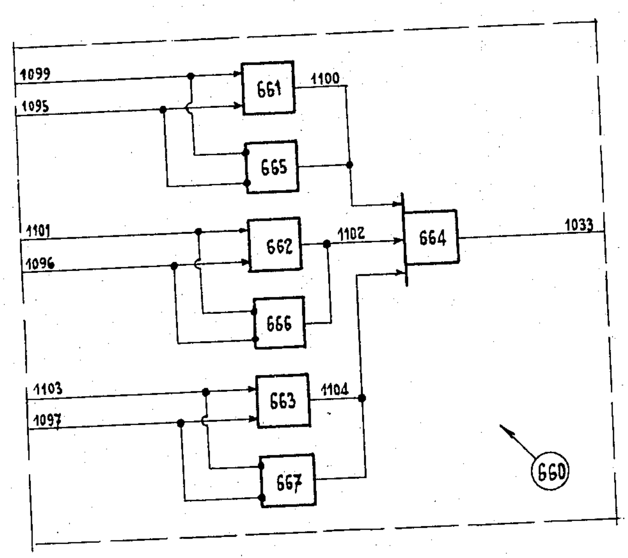
740

—Fig. 21—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663
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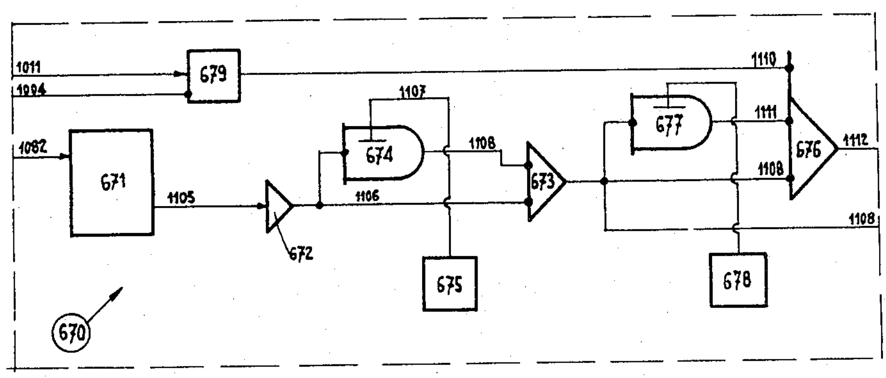
660

—Fig. 22—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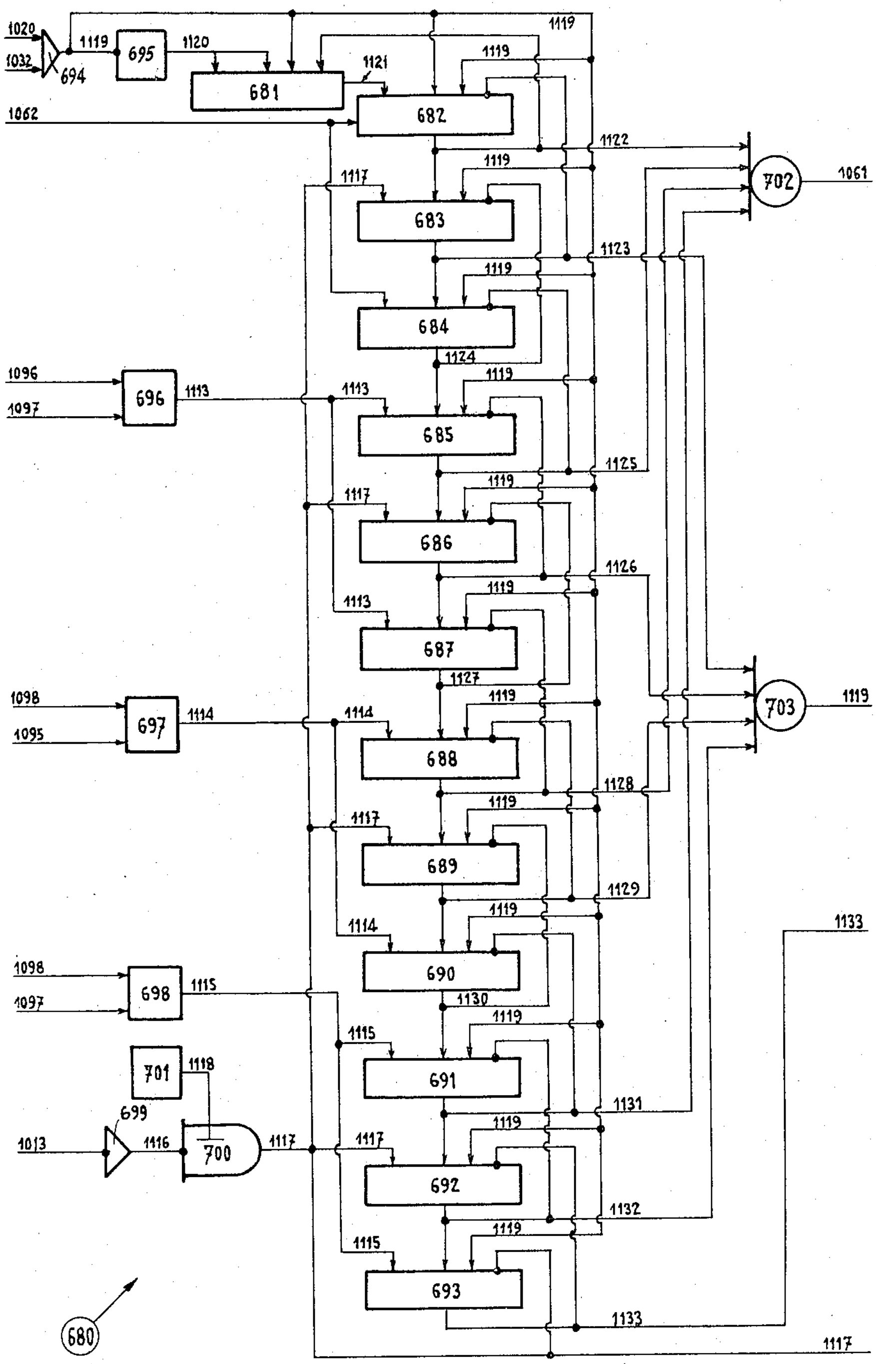
675
678
670

Fig. 23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1129
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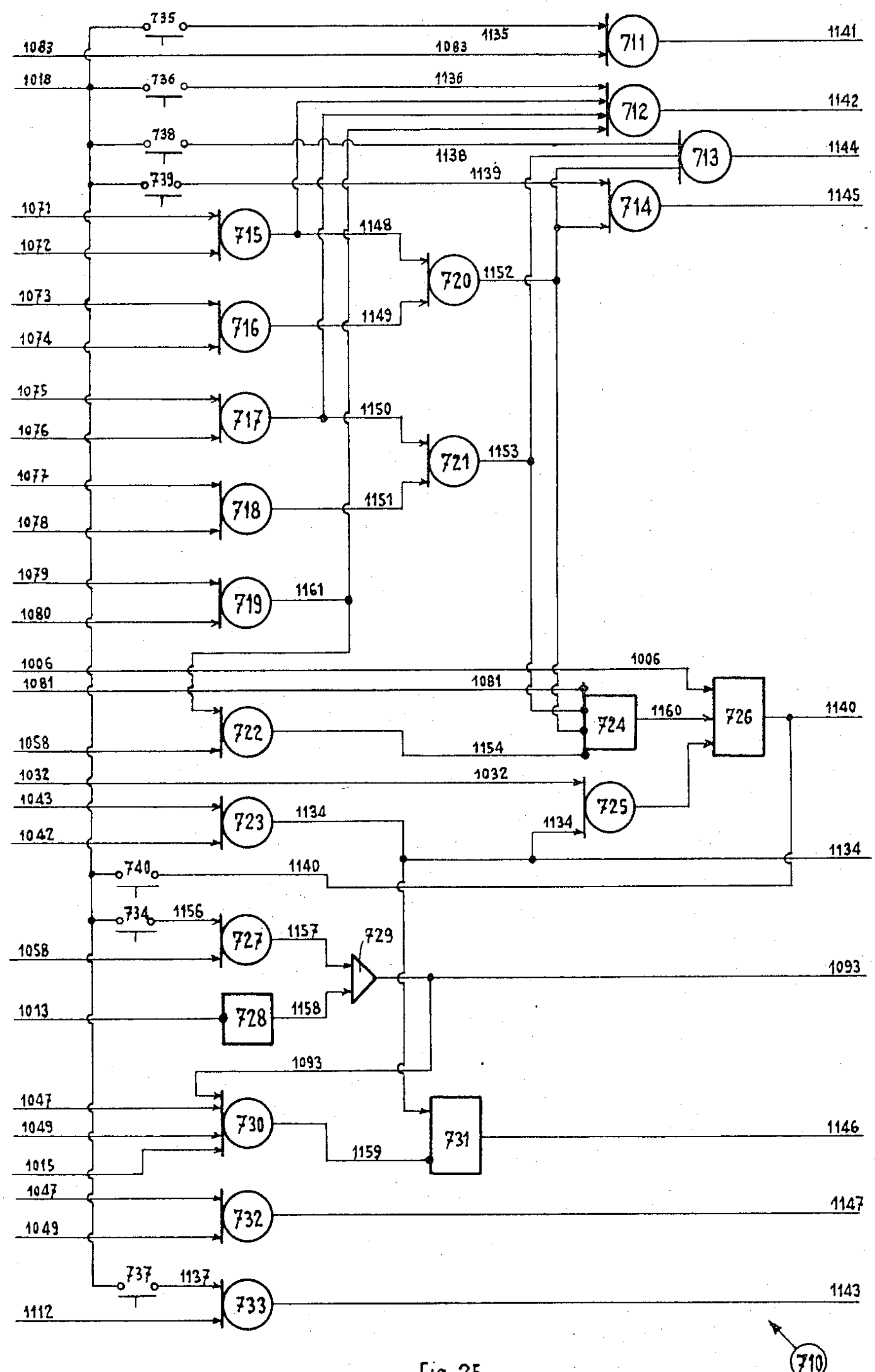
Fig. 24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733
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1112
710

Fig. 25

United States Patent Office

3,372,106
Patented Mar. 5, 1968

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3,372,106

MACHINE AND METHOD FOR CRUST PIERCING AND FEEDING OF MOLTEN ELECTROLYTIC BATHS

Jacques Chambran, Tarascon-sur-Ariege, France, assignor to Pechiney, Compagnie de Produits Chimiques et Electrometallurgiques, Paris, France

Filed Sept. 23, 1964, Ser. No. 398,566
Claims priority, application France, Sept. 24, 1963, 948,473
25 Claims. (Cl. 204—245)

ABSTRACT OF THE DISCLOSURE

A machine for feeding powdered alumina into molten baths having a crust on the surfaces thereof and through which anodes extend into the baths for the production of aluminum by electrolysis and in which a plurality of such baths are aligned in side by side spaced apart relation, said machine comprising a carriage and means for displacement of the carriage from a starting position to a position in front of the baths, a piercing hammer mounted on the carriage for displacement vertically between raised and lowered positions and means responsive to the resistance to penetration of the hammer through the surface of the bath for initiating the operation of the piercing hammer to form an opening through the crust, a hopper on the carriage for the storage of alumina and means for discharging alumina from the hopper into the opening pierced by the hammer, said machine embodying sequencing and control means responsive to the position of the carriage relative to the baths and responsive to the position of the piercing hammer between raised and lowered positions adapted to (1) displace the carriage to a position in front of the anode of the bath to be fed, (2) lower the piercing hammer responsive to positioning of the carriage to pierce the crust to form an opening through the surface of the bath, (3) raise the piercing hammer from the bath, (4) displace the carriage a short distance responsive to movement of the hammer towards raised position, (5) pierce the bath again and continue the operation of steps (2), (3) and (4) until a number of openings have been provided in the surface of the bath, (6) feed aluminum from the hopper onto the surface of the bath, and (7) displace the machine to starting position.

This invention relates to a machine for feeding raw materials to baths for fusion electrolysis and relates more particularly to a machine for use in the production of aluminum by electrolysis to pierce the crusts and to feed powdered ingredients into the molten production bath.

In accordance with past practices, the crusts formed on the surfaces of the molten baths of alumina were perforated manually at portions selected by experience by the operators for purposes of gaining access to the interior of the bath for feeding alumina and the like powdered raw materials into the molten bath.

In the French Patent No. 1,245,598, description has been made of the machine for piercing and distributing alumina into electrolytic baths. The operation as described in the aforementioned patent is characterized with a number of deficiencies from the standpoint that it is incapable of controlling the piercing and the feeding operations uniformly to distribute the introduction of alumina over the surfaces of the molten baths. It is believed that the problems raised by such machines can be obviated by a machine which operates automatically to effect piercing and feeding operations in compliance with a set program and preferably a predetermined program.

2

It is an object of this invention to produce a machine which operates automatically to pierce and feed baths for fusion electrolysis and in which the machine is capable of controlling feed on a predetermined program preceded by a piercing operation.

More specificially, it is an object of this invention to produce a machine which is automatic in operation, which can effect a piercing operation to perforate the crusts formed on surfaces of molten electrolytic baths, which can effect a feeding operation to introduce particulate feed material through the perforations formed in the crusts, which is programmed to carry out the perforating and feeding operations at points regularly distributed over the surfaces of the baths, which is capable of operation without human intervention automatically to control the piercing and feeding operation and the distribution of feed into the baths, which is relatively simple in construction and easy in operation, which is capable of steady operation over long periods of time to maintain the health of the baths for the production of aluminum by electrolysis, and which is flexible in operation to control the feed to any number of baths making up the pot line.

The machine, embodying the features of this invention, will hereinafter be described with reference to a specific use in the production of aluminum by electrolysis wherein a plurality of electrolytic cells are arranged in spaced-apart relation along a line to form, what is referred to in the trade as a pot line, and in which the baths are fed with powdered alumina for reduction to a molten state by the heat generated during passage of electrical current from anodes, which extend downwardly into the molten bath, to the cathodes whereby the alumina is reduced to metallic aluminum which collects as a molten metal at the bottom of the bath for removal as product while the molten material at the surface of the bath is exposed to ambient temperature to form crusts which are required to be pierced for feeding alumina into the bath.

The machine according to the invention comprises in combination a carriage forming a general supporting structure and comprising means which allow it to be displaced in front of the baths in question, the piercing and feeding operations taking place during the displacement; a piercing hammer controlled by a fluid under pressure and mounted on a jack which allows a vertical translatory movement to be imparted to it, the two pieces of apparatus being fed in parallel by the same under pressure fluids so that the hammer does not begin to function until the resistance of the crust arrests the descending translatory movement; an alumina hopper equipped with a dosing receptacle and a valve enabling the contents of the receptacle to be discharged, the hopper being set back from the piercing hammer in the direction of displacement of the machine during the piercing operations; a sequence mechanism, controlled by a time switch, and positioning members of which some are located on the bath to determine the position of the carriage and others on the piercing hammer to determine whether it is in the raised or lowered position, and which actuate proximity detectors mounted on the apparatus. It carries out the following operations:

(a) While the machine is in its starting position, at the head of the series of baths in question, filling of the alumina hopper from a silo provided for the purpose;

(b) Starting of the machine until it is in front of the anode opposite which the crust covering the liquor has to be pierced;

(c) Piercing the crust in front of the anode in question at a certain number of points, the machine moving a slight distance each time at least one point has been pierced;

(d) After piercing at a given number of points, the discharge into the bath of the alumina contained in the dosing receptacle;

(e) Repetition of the above piercing and feeding operation opposite a certain number of anodes; and,

(f) Return to the starting point after a given number of feeding operations, and refilling of the hopper from the silo disposed for this purpose.

In a preferred embodiment, the sequence mechanism also has a supplementary member controlled by an anode known as the "pilot anode" of the bath, which blocks the alumina-feeding mechanism as soon as the dissolved alumina content of the liquor reaches a value of between 4 and 7 percent, and which frees this mechanism as soon as the content drops to a value between 1.5 and 4 percent.

In a special embodiment of the invention, each series of electrolytic baths is equipped with two automatic machines located one on each side of the baths. One proceeds with the piercing operation as a function of a definite program whereas the other is kept in reverse to answer summons triggered off by the phenomenon of anodic polarization, known as "burning" of one of the baths or even by "preburning" as will be explained hereinafter. The functions of the two machines is reversed after a given period of time or a given number of runs.

The foregoing objects and other objects and advantages of the invention will hereinafter be described and for purposes of illustration, but not of limitation, embodiments of the invention are shown in the accompanying drawings in which:

FIGURE 1 is a diagram of the piercing cycle in the system of baths with prefired anodes;

FIGURE 2 is a perspective view of the moving portions of the machine embodying features of this invention;

FIGURE 3 is a digrammatic elevational view showing the winch assembly;

FIGURE 4 is a diagrammatic elevational view of the assembly which includes the pneumatic hammer and means for its control fixed on the framework of the machine;

FIGURE 5 is a diagrammatic view in elevation of the pneumatic circuit controlling the piercing hammer and the alumina feed;

FIGURE 6 is a diagrammatic elevational view of a means for feeding alumina;

FIGURE 7 is a schematic view of a differential doubled-bodied jack used to pierce the top of the baths or to carry out the piercing operation in more than two lines in front of the anodes;

FIGURE 8 is a diagram which shows the piercing points at the head of a first bath anode;

FIGURE 9 is a longitudinal diagram which shows the position of the proximity detectors on the machine and their energizing members on the bath and it relates to a series equipped with two machines located on each side of the baths;

FIGURE 10 is a transverse diagram of the elements in FIGURE 9 to show the position of the essential members of two machines serving the same series of baths;

FIGURES 11 to 25 are partial diagrams of the controlling sequencing apparatus in which the elements are represented by numerals within the range of 500 to 733 and in which the leads are represented by numerals above 1000.

In FIGURES 11 to 25, the partial diagrams can be connected by joining the leads bearing the same numerals. FIGURE 11 shows the means for signaling the position of the carriage and of the hammer **540**. FIGURE 12 shows the starting means **550**. FIGURE 3 shows the timing means **560**. FIGURE 14 shows the memory of the piercing assembly **570**. FIGURE 15 shows the memory of effective piercing **580**. FIGURE 16 shows the means controlling unpacking after burning and preburning **590**. FIGURE 17 shows the memory of unpacking after burning **600** in which unpacking refers to the elimination of the effect of an anodic polarization. FIGURE 18 shows the generator of the impulse which starts the piercing operation **610**. FIGURE 19 shows the memory of the return of the carriage **620**. FIGURE 20 illustrates the record of piercing **630**. FIGURE 21 shows the counter F **740**. FIGURE 22 shows the coincidence circuit **660**. FIGURE 23 shows the pairs counter **670**. FIGURE 24 shows the record of returns **680**. FIGURE 25 shows the means controlling the electrical valves and the motors **710**.

In FIGURES 11 to 25, the logical members are represented by conventional signs, since the details of each member are well-known to those skilled in the art. On each member, an energizing input, that is to say, an input causing a signal to appear at the output of the member, is represented by an arrow whereas a prohibition or blocking input, i.e., an input causing the signal to be suppressed at the output of the member, is represented by a dot. A member which recurs frequently in the diagrams is the "OR" circuit, for example **542** in FIGURE 11. The output of this member emits a signal each time at least one of its inputs in energized. The member is represented by a circle with the inputs ending in a segment of a straight line at a tangent to the circle and the output diametrically opposed to the point of contact of the tangent. Similarly, the "AND" circuit occurs frequently, for example **543** in FIGURE 11. The output of this member emits a signal each time all its inputs are energized simultaneously. It is represented by a square or rectangle with the inputs ending at one of its sides and the output or outputs extending from the opposite side. An "OR" circuit comprising at least one blocking input is sometimes described as an "OR-NOT" circuit, while an "AND" circuit, comprising at least one blocking input, is similarly sometimes called an "AN-NOT" circuit.

The operation of the automatic machine is based on a certain number of principles which applicants have established either as a result of experiments accompanied by exact measurements and carried out on industrial baths selected from a series, or as a result of experiments of long duration carried out on entire series of baths. These principles are as follows:

The alumina content of the liquor must not be substantially lower than a minimum content of the order of 2 percent;

The energy yield of the operation is increased when the alumina content of the liquor is increased from this minimum value;

The alumina content of the liquor must not be substantially greater than a maximum content, for example of the order of 7 percent; and

When said minimum content is detected, the crust is pierced and the liquor fed with alumina, preferably in several stages, until the alumina content of the liquor substantially reaches the maximum.

Observation of these principles results in a saving in electricity and in the consumption of fluorine containing products in the electrolytic liquor. If the alumina content is kept between two limits in this way, it becomes possible first to prevent "burning" and second to prevent the addition of surplus alumina to the liquor from resulting in deposits of this oxide of the cathode in the bath. These deposits have been found to be particularly harmful both to the normal course of the electrolytic operation and to the preservation of the cathode. The said regulation of the alumina content also permits a substantial increase in the means dissolved alumina content of the liquor which results in an improvement in the energy yield from electrolysis.

In French patent application No. 909,846, filed Sept. 19, 1962, under the title "Improvements to Igneous Electrolysis of Alumina" and in the first addition to this application, filed Sept. 3, 1963, under No. 946,411, applicants described a process for detecting the dissolved alumina content of the electrolytic liquor. In this process, a current impulse is passed through an anode which is known as the pilot anode and the base of which is of small surface relatively to the total anodic surface. The impulse is such that the base is crossed by a current of greater density than that "d" of the current passing through the anodic surface of the bath during normal operation, preferably from 1.5 to 10 times this density "d" and from 1 to 10 A./cm.^{2}, more particularly from 2 to 6 A./cm.^{2}. The voltage of the pilot anode is measured for the duration of this current impulse. The impulse is repeated systematically until the voltage of the pilot anode exceeds a value, known as the volt-rise value, which is greater than the maximum value observed during the preceding impulses, and preferably between 1.05 times and twice this value. By means of the volt-rise at the pilot anode, the time is detected when the dissolved alumina content of the liquor drops below a given threshold (limit value) which depends on the impulse density chosen. A so-called "preburning" signal is sent to the piercing and feeding machine as soon as polarization takes place for a current density, chosen at random within the limits defined above, corresponding either to the minimum or to the maximum dissolved alumina content of the bath to be detected.

The machine according to the invention is suitable to carry out this process or any other process for preventing burns. The machine thereafter operates as follows. In normal operation, if no signal is emitted by the pilot anode, the machine pierces and provisions in a set rhythm slightly faster than the rhythm of normal consumption of alumina. The alumina content of the liquor thus increases and, after a certain number of piercing and feeding operations, reaches the set upper limit. The pilot anode then emits a signal to prohibit feeding. The machine continues to pierce the crust but no longer feeds the bath, and the alumina content of the liquor drops and finally reaches the lower limit. The signal prohibiting feeding is then withdrawn, and feeding with alumina is continued.

The piercing of the crust may be discontinuous with the whole of each bath being pierced before the next bath, or continuous with each bath being pierced over a fraction of its length, for example over the length of one anode in the case of multiple-anode baths, prior to the next bath being pierced over the same fraction of its length. Piercing may be carried out in one or more lines, but applicants have found that for present day industrial baths with prefired anodes or anodes of the "Soederberg" type, the best results are obtained by piercing along two lines.

The number of machines used per series of baths depends on the size of the series. In the case of short series with a small number of baths, one machine is sufficient. It will then turn back on itself at the end of the series so as to serve both sides of the series in succession. In the case of series of medium length, two machines will be used, each serving one side of the series. The turn at the end of the series is thus avoided. In the case of very long series, several machines may be provided on each side.

By way of example, a description will now be given of a machine designed to serve one side of a series of fifteen 50-kiloamp baths with prefired anodes for alumina electrolysis. Each bath has 12 anodes, six at each side. The machine described carries out its useful work, piercing and feeding during displacement in a certain direction, which is always the same, and is described as the "working direction." It does no work during its displacements in the reverse direction, described as the "returning direction." This results in simplification of the controlling electronic circuits, although any other arrangement is possible.

The elementary piercing operation, known as the "piercing cycle," comprises eight piercing points, four points **1**, **3**, **5**, **7** in the front position, i.e., in the vicinity of the anode, and four points **2**, **4**, **6**, **8** in the rear position, i.e., near the wall of the bath. The piercing cycle is repeated in front of each anode. When the machine is being displaced in its working direction and the hammer arrives at right angles to the anode **21** to be pierced, it goes into the front position above the point **1**. It descends and strikes as soon as it meets resistance. As soon as the hammer has reached the low position, or if it fails to reach the low position, after a period of time, t_1, it rises again. At the end of its stroke in the raised position, the hammer passes into the rear position below the point **2**, redescends and pierces the crust. The machine starts again, stops, pierces the points **3**, then **4**, and so on. When the point **8** has been pierced, the machine starts up again in the working direction **20**, and either recommences the cycle in front of the following anode **22** in the same bath, in the case of discontinuous piercing, or reaches the following bath and repeats the operation in front of the corresponding anode in the case of continuous piercing. In both cases, when the hammer has pierced the point **8**, then covered a distance l corresponding to a travelling time t_2 and thus arrives at **9**, the dosing receptacle of the feeding hopper opens so that the pierced zone is covered with alumina.

The whole piercing cycle is repeated in front of each anode.

The moving part of the machine consists of a frame **100** comprising a tubular frame **110** and an upper frame **120** supporting the controls. The lower part of the tubular frame carries a wheel **111** which freewheels along the floor of the electrolytic workshop, while the upper frame carries two driving wheels **121** and **122** controlled by the motor **124**.

The upper frame **120** also carries the various pieces of apparatus which will now be described. Fixed on the frame **120** are the winches and their mechanism, the assembly bearing the reference **200** and comprising a winch **210** for a flexible lead **211** bringing the compressed air necessary for the pneumatic controls, and its controlling motor **212**. The flexible lead **211** passes over pulleys **213** (not shown in FIGURE 2 for reasons of clarity) and **214**. A winch **220** for the electric cable **221** feeds the pieces of apparatus with electricity, and its controlling motor **222**. The cable **221** passes below the drum of the winch **210** into a guiding spout **223**.

Fixed below the frame is all the mechanical, electrical and pneumatic apparatus proper, that is to say the assembly **300** comprising the pneumatic hammer and its control means, the alumina-feeding assembly **400** and the sequence control assembly **500**.

The assembly consisting of the pneumatic hammer and its control means comprises the hammer proper **301**, of which the pick **306** is extended by a rod **307** adapted to slide in a cylindrical space **304** in the body of hammer. This space opens into a compressed air chamber **303**, but communication between these two spaces may be interrupted by means of the obturator **305**. The rod **307** contains an indentation **308** which restricts the stroke of the pick **306** by means of the bush **309** rigidly fixed to the body of the hammer. The hammer may perform a rising or descending vertical translatory movement by means of a differential jack having two outlets **310**, the shaft **311** of which is linked to the upper frame **120** by means of a Cardan suspension **302** (not shown in detail in FIGURE 5), and the body **302** of which is rigidly connected to the piercing hammer **302**. The volume **314** of the jack **310** above the small face of the piston **313** is in constant communication with the supply for the general pneumatic circuit **331** fed by the cable **211**, while the volume **315** below the large face of the piston communicates with the pneumatic circuit by means of a valve with electrical controls or electric valve **332** also controlling the piercing hammer **301**. When the jack **310** is open, the hammer is in the low position.

The hammer operates as follows. When the electric valve **332** is not energized, the volume **314** is in communication with the circuit **331**, thus keeping the jack closed. The hammer is in the raised position. When the electric valve **332** is energized, the volume **315** is also put into contact with the circuit **331**. The force applied to the large face overcomes the force applied to the small face of the piston **313** and the jack opens. However, the pressure of the pneumatic circuit, transmitted to the space **303**, repels the obturator **305** and thus closes the inlet to the space **304**. As soon as the pick encounters resistance, the rod **307** rises in the space **304**, repels the obturator and thus allows the compressed air present in the space **303** to act on the rod **307**. The pick **306** is repelled and the hammer strikes a blow. The obturator **305** is again repelled and the operation recommences. When the electric valve **332** is no longer energized, the hammer stops striking and ascends to the raised position. The jack **310** may either be rigidly connected to the hammer or independent thereof.

The body **312** of the jack **310** carries a plate **533** while the frame **120** carries two devices for detecting the position of the hammer, namely, the raised position detector **516** which is opposite the moving plate when the hammer is in the corresponding position, and the lowered position detector **517** which is opposite the same plate in the corresponding position of the hammer. The two detectors provide references for setting the position of the hammer, the lower position detector cutting off the supply of electricity to the electric valve **332** as soon as the hammer comes into the lowered position and thus causing the hammer to move into the raised position.

Within the vertical plane perpendicular to the axis of the series of baths, the hammer can take up several inclinations by the action of a differential jack with two outlets **320**, in which the shaft **321** of the piston **323** is connected to the body **312** of the jack **310** carrying the hammer by a resilient means such as a spring jack **326** which enables the hammer to take on an inclination greater than that resulting from the position of the jack **320**, and by the action of a lateral force directed towards the axis of the bath. The spring jack **326** may be incorporated in the output shaft **321** of the differential jack **320** as shown in FIGURE 4. The volume **324** of the jack **320** located in front of the piston **323** communicates directly with the general pneumatic circuit **331**, while the volume **325** to the rear of the piston **323** communicates with the circuit **331** through the electric valve **333**. The body **322** of the jack **320** is fixed onto the tubular frame **110** by means of the jack-holding support **112**.

The device operates as follows. When the electric valve **333** is not energized, only the small face of the piston **323** is fed. The jack **320** is closed and the piston is in the rear position. The hammer then pierces a point such as **2**, **4**, **6** or **8**. By means of the jack **326**, it can slide along the ramp and scratch the latter. When the electric valve **333** is energized, both faces of the piston **323** are fed but the force applied to the large face, i.e., the rear face, overcomes the force applied to the small face. The jack **320** opens and the hammer moves into the forward position. It can then pierce a point such as **1**, **3**, **5** or **7**.

The hammer is guided in this movement by a hammer guide comprising two blades **341** and **342** of which one end is articulated to the hammer **301** and the other end to a plate **343** which is fixed to straps **344** articulated at **345** to a support **123** rigidly connected to the upper frame **120**. The straps also support the jack **320–326** at **346** and possibly a jack **350** which will be described hereinafter. This arrangement gives great flexibility to the suspension of the piercing hammer.

The alumina feeding assembly **400** comprises a hopper **410**, a deformable diaphragm valve **420** and a dosing receptacle **430** of specific capacity.

The hopper **410** comprises at least one air guide **411**. The function of the guide is to encourage the alumina to pass into the valve **420**, and it comprises a cloth or porous slab **413** through which a current of gas is passed, for example a current of air taken from the pneumatic circuit **331**. The hopper is completed (FIGURE 6) by a device **414** which shuts off the inflow of alumina as soon as the hopper is full. The device illustrated comprises a small electric motor **415** driving the propeller **416**. When the alumina reaches the level of the propeller, the movement of the latter is braked with the aid of any mechanical or electrical means. This causes a relay controlling an electric valve to close and thus arrests the inflow of alumina. Feeding may be automated by a device **440** comprising the following:

Fixed on the hopper **410**, the relay **441** controlled by the device **414** when the hopper is full, the relay being connected to an energizing winding DP E*x* **442** by the lead **1172**, and a plate **448**; and,

Fixed on the storage silo **447** which feeds the hopper **410**, a detector DP1 **443** energized by DP E*x*, another detector DP2 **444** and the two relays **445** and **446**.

The relay **445** is energized by DP1 whereas the relay **446** is energized by DP2 but by means of the movable relay **445** contact. The movable contact of the relay **446** acts, by means of the lead **1173**, on the electric valve (not shown) controlling the discharge of alumina from the silo **447** into the hopper **410**.

The signal TR transmitted by the lead **1172** constitutes a prohibition in the return memory **620** described hereinafter.

The valve **420** comprises a diaphragm **421** behind which compressed air taken from the pneumatic circuit **331** can be sent into the space **422** by means of the electric valve **423**. The outer wall of the valve contains a small aperture through which compressed air can flow. The valve remains thus closed only so long as pressure is applied at **422**.

The dosing receptacle **430** comprises the bottomless receptacle **431** and the rocking base **432** actuated by the pneumatic jack **433** which is connected to the electric valve **423** in parallel with the valve **420**.

The feeding device **400** operates as follows. Assuming that the hopper **410** is full, the air guide **411** which is still fed drops the alumina into the bottom of the hopper. When the electromagnet of the electric valve **423** is not energized, the compressed air presses neither into the space **422** in the valve **420** nor into the jack **433**. The receptacle **430** is closed, the valve **420** is open, and the receptacle is filled with alumina. When the electromagnet of the electric valve is energized, the compressed air passes both into the space **422** in the valve **420** and into the jack **433**. The valve **430** is closed while the dosing receptacle is open. The dose of alumina is discharged onto the electrolytic liquor in the bath above which the machine is standing.

The apparatus described enables one side of the electrolytic baths in the series to be pierced longitudinally along two lines and the pierced zones to be fed with alumina following the cycle shown in FIGURE 1.

If it is desired to pierce along one line only, the jack **320** is eliminated.

If, on the other hand, it is desired to pierce along more than two lines or else to pierce the heads of the baths, then a differential double-bodied pneumatic jack **350** is placed in series with the jack **320**.

The jack **350** comprises two jack bodies **351** and **352** separated by a wall **353**, and two pistons **354** and **355**. The shaft **356** of the first piston is connected to the jack **320**, while the shaft **357** of the second piston is connected to the holding support **112** fixed to the frame. The two outer chambers **358** and **359** of the two jack bodies are permanently connected to the general pneumatic circuit **331**, and the two inner chambers **360** and **361** of these two bodies are connected to the same circuit **331** by means of two electric valves **362** and **363**, respectively.

When neither of the two electric valves is energized, only the outer chambers **358** and **359** are under pressure. Each of the two pistons is at the bottom of its respective chamber in the position shown in FIGURE 7. The jack **320** is in the normal working position for the piercing cycle shown in FIGURE 1. When only one of the electric valves is energized, the corresponding piston comes to the top of its chamber, and the hammer is in its first piercing position. When both electric valves are energized, both pistons are in the outer position and the hammer occupies its second piercing position.

By making the strokes of the two jacks and thus the two bodies **351** and **352** of different lengths, an extra piercing position can be obtained.

In the case where the stroke of the two jacks are equal, there are thus four positions **11** to **14** for piercing the head of the anode **10**, these being in addition to the front-line and rear-line positions in FIGURE 1:

Electric valves **333**, **362** and **363** not energized, piercing rear line, point **2**;

Electric valve **333**, energized, **362**, **363** not energized, piercing front line, point **1**;

Electric valves **333**, **363**, not energized, **362** energized, piercing at the head, point **11**;

Electric valve **363**, not energized, **333**, **362** energized, piercing at the head, point **12**;

Electric valve **333**, not energized, **362**, **363** energized, piercing at the head, point **13**;

Electric valves **333**, **362**, **363**, energized, piercing at the head, point **14**.

The sequence control assembly **500** comprises members supplying the input signals, namely proximity detectors located on the moving part of the machine and members for energizing these detectors, located on the series of baths. The detectors are:

The detectors of the position of the machine relatively to the series, DPA, reference **511** and DPB, reference **512**;

The detectors of the position of the machine relatively to a bath, DPC, reference **513** and DPB, reference **514**;

The detector of the position of the machine with a view to piercing in a case of preburning, DPE reference **515**;

The detectors of the position of the piercing hammer, DPH, reference **516** for the raised position and DPI, reference **517** for the lowered position; and,

The detector responsible for blocking the supply of alumina to a bath, DPF, reference **518**.

The energizing members are:

The plates **521** energizing the detectors DPA **511** and DPB **512** when the machine is at the end of the series;

The plate **522** energizing DPA **511** when the machine is in position for piercing at the head at the end of a bath;

The plate **523** energizing DPB when the machine is at the beginning of the series;

The winding **524** energizing DPE **515** at the beginning of a piercing operation in the case of preburning;

The seven plates **525** to **531**, including the retractable plate **526**, designed to energize DPC and DPD simultaneously in pairs when the machine is in position in front of an anode to initiate piercing thereof;

The retractable plate **532** energizing DPF to prohibit the feeding of a bath with alumina; and,

The plate **533** which energized DPH **516** when the piercing hammer is in the raised position and DPI **517** when the hammer is in the lowered position.

The input signals emitted by these members act on the electric valves and on the electric motor actuating the carriage by means of logical elements and memories, the arrangement of which depends on the program imposed on the machine.

The machine described permits the following automatic operations:

Discontinuous preventive piercing, hereinafter referred to as "A programs" or "A piercing," wherein the machine continually pierces each bath and feeds it with alumina. Every *x*th (e.g. third) bath, the machine returns to the head of the series to restock with aluimna. It then sets off again to pierce the successive baths;

Continuous piercing, hereinafter referred to as "B programs" or "B piercing," in which the machine carries out a piercing cycle in front of each anode over each bath. The *n*th anode being pierced successively over each bath in the series in the course of a "run" before the $(n+1)$ anode is in turn, in the course of the following "run." After piercing all the anodes the machine comes back into position at the starting point;

Piercing for burning or preburning unpacking, described as the "C program" or "C piercing." When the anodic system of a bath is polarized, the voltage rise at the terminals of the bath is translated by a signal; "burning unpacking." Similarly, when the pilot anode, fed at a higher current density than the normal anodes of a bath, is polarized, the voltage rise between the pilot anode and the cathode of the bath is translated by a signal known as "preburning unpacking." In both cases, the machine carries out a complete piercing operation identical with "A piercing," over the bath; and,

Feeding with alumina after each piercing cycle. The feeding operation being arrested only when a "feeding prohibited" signal is emitted, indicating that the dissolved alumina content of the liquor has exceeded the fixed maximum. This signal disappears when said content has dropped below the fixed minimum.

The series of fifteen baths is equipped with two identical machines disposed symmetrically relatively to the vertical plane containing the center of the baths.

For this purpose, two rails comprising irons **91** and **92** symmetrical relatively to the same plane are arranged above the series. The upper wheels such as **121** and **122** of the corresponding carriage move along each of these rails. The irons **91** and **92** may, for example, be U-irons or I-irons. In the latter case, lateral belt guides hold the wheels onto the rail.

During the A program, one of the machines carries out the discontinuous piercing operation while the other is kept in reserve and responds only to burning summons. After a given time, the two machines are reversed.

During program B, one of the machines carries out the continuous piercing operation while the other is held in reverse and responds to burning or preburning summons. When the first machine has pierced each of the anodes in each bath, corresponding to as many runs as there are anodes per bath, i.e., six in the present case, the roles of the two machines are reversed.

During program C, provision is made only for burning and preburning unpacking. In this case, the two machines carry out burning and preburning unpacking operations simultaneously, the burning signal emitted by a bath in the series having priority over any preburning signal which may be emitted at the same time by a different bath.

The apparatus comprises the members which will now be described.

The means for signalling the position of the carriage and hammer **540** supplies electrical signals conveying the longitudinal position of the carriage and the transverse position of the hammer.

The "AND" element **543** supplies a signal at **1008** only on condition that its two inputs are energized simultaneously, i.e., on condition that two detectors DPC **513**, DPD **514** are energized simultaneously. The detectors are in fact connected to these inputs by leads **1001**, **1002**. The signal emitted at **1008** corresponds to the "beginning of bath to be pierced" position of the carriage and to the logical combination $DPC \times DPD$.

The "AND" element **544** has its inputs connected respectively to the detector DPD **514** by **1002**, to DPC **513** by **1001** and to DPE **515** by means of a memory formed by a rocker **541**. A signal $DPC \times DPD \times DPE$ is emitted at **1009** on condition that these three inputs are energized simultaneously, corresponding to the "beginning of piercing in a case of preburning" position of the carriage.

Similarly the "AND" element **545**, of which the inputs are connected to DPC **513** by **1001** and to DPE **515** by **1010** at the output of the memory **541**, emits a signal $DPC \times DPE$ at **1012** corresponding to the "beginning of piercing in a case of burning" position.

The signal DPE 1003, which is produced only when the carriage passes opposite the energizing coil 524, is memorized by a rocker 541 which supplies a signal at 1010 only if its two positive inputs are energized simultaneously by the signals transmitted by 1019 and 1003 and if its prohibiting input, which is connected by the "OR" circuit 542 to the three conditions HE 1047, JE 1049 and K 1058 to be defined hereinafter, is not energized.

The "AND-NOT" element 546 and the "AND" element 547 are energized in parallel, one of their inputs being connected by 1004 to DPA 511 and the other by 1005 to DPB 512. The element 546 supplies a signal only if DPA 511 is not energized and if DPB 512 is. It then supplies the signal $\overline{DPA} \times DPB$ at 1013 corresponding to the starting point of the series. The element 547 supplies a signal at 1014 only if the two detectors are energized simultaneously, corresponding to the "end of series" position $DPA - \times DPB$.

A signal 1015 representing DPE 515 memorized is also drawn from the rocker circuit 541 without being prohibited by 542.

The detector DPF, reference 518, provides an output at 1011.

The starting means 550 comprises a master relay RMA, reference 551, connected to the lead 1016 coming from a source of current such as the electricity mains by means of a general switch controlling the whole installation (not shown). When the relay is engaged, it makes a signal RM appear on the lead 1017 and feeds the power amplifiers of the electric valves and the switch 552.

The switch 552 has two positions: manual control, when the upper contact is closed and the lower one open (the current is then transmitted by the lead 1018) and, automatic control when the lower contact is closed and the upper one open (the current is then transmitted to the lead 1019 on which appears the signal RMA).

The lead 1019 is connected to the input of the three contacts of the switch 553. Closing of one of the contacts of 553 causes the other two to open. The upper contact, corresponding to program A, feeds the lead 1020. The middle contact, corresponding to program B, feeds the lead 1021, and the lower contact, corresponding to program C, acts on the lead 1022.

The leads 1020 and 1021 act on the "OR" circuit 554 which supplies a signal ("A or B") at 1170 when there is a voltage on one or other of its inputs. 1170 acts on the "AND-NOT" element 557 which acts via 1023 on one of the inputs of the "AND" element 555, the other input of which receives the signal $\overline{DPA} \times DPB$ 1013. If the two inputs are energized simultaneously, 555 transmits to the lead 1024 a signal MM which is applied in turn to the element 556. By means of the lead 1025, the element 556 transmits an impulse RMP 1 which is retarded relatively to the signal MM.

The timing means 560 comprises the relay 561 of which the input is connected to the lead 1025. It is thus released by the signal RMP 1. The relay actuates the time switch 562 by means of the lead 1026, and the time switch transmits impulses constituting the signal MN at regular intervals via 1027. These impulses are stored in the binary counter D, known as the run counter, reference 563. The counter comprises three memories respectively supplying the signals D1 1099, D2 1101 and D4 1103. The first impulse actuates the first memory, giving a signal D1. The second impulse actuates the second memory, giving a signal D2, and reblocks the first memory, thus effacing the signal D1. The third impulse again actuates the first memory, re-establishing the signal D1 without affecting the signal D2, which remains. The fourth impulse acts on the first memory and effaces D1, then the signal from the first memory acts on the second by effacing D2, and the signal from this second memory acts on the third, causing D4 to appear. The fifth, sixth and seventh signals act on the first two memories exactly like the first, second and third signals, without affecting the third memory and thus without effacing D4. The signal D7 resulting from the simultaneous existence of D1, D2 and D4 is obtained by the "AND" element 564 which has three inputs respectively connected to D1 1099, D2 1101 and D3 1103 and which transmits the signal D7 at 1028 when these three inputs are energized simultaneously.

When the "OR" circuit 565 is acted on by D2 1101 and D4 1103, it supplies a signal D2 or D4 at 1052.

The signals MM and MN release the memory of piercing.

Piercing comprises piercing at the head, which can be split up into eight operations, namely:

R1, translation of the piercer to 14 and piercing at 14;
R2, raising of piercer;
R3, translation of piercer to 13 and piercing at 13;
R4, raising of piercer;
R5, translation of piercer to 12 and piercing at 12;
R6, raising of piercer;
R7, translation of piercer to 11 and piercing at 11; and,
R8, raising of piercer;

and piercing in front of the anode, which can be split up into four operations repeated four times, namely:

R9, translation of piercer to 1 and piercing at 1;
R10, raising of piercer;
R11, translation of piercer to 2 and piercing at 2; and,
R12, raising of piercer.

The above symbols represent both the operation and the signal giving rise to it.

The piercing memory assembly 570 comprises a first memory 571 which is fixed to the operating cycle, i.e., to the signal R1 by the lead 1071 and to the "program A" signal by 1020, and which is blocked by the signal D7 of 1028. The memory 571 controls the principal piercing memory 573 by means of the "AND-NOT" element 572. When acted on by 1030 this element transmits a signal to 1031 when the two signals MN provided by 1027 and $\overline{DPA} \times DPB$ provided by 1013 are both present and when the signal emerging from 571 via 1030 is absent. The signal G emerging via the lead 1032 constitutes a piercing order.

The memory of effective piercing 580 comprises the memory 581 which gives a signal "GE" to 1034 to denote the presence of the carriage on the bath to be pierced; and the memory 583 which gives the piercing proper signal "GF" to 1036.

This second memory is actuated by the first and is thus not actuated until after the first.

The memory 581 is acted on by the signal "G" 1032 and by the signal $DPC \times DPD$ 1008, and it is not actuated unless these two signals are present simultaneously.

The memory 583 is actuated by GE and by the signal emerging via 1035 from the "OR" circuit 582, which is itself acted on by the "program A" signal at 1020 and by a so-called coincidence signal Γ at 1033. The two memories receive a prohibition signal via 1171, emanating from the "OR" circuit 585, the four inputs of which receive respectively:

A signal emerging at 1162 from the "AND" circuit 584 which is acted on by DPA 1004 and R8 1078;

A return signal K 1058;

The signal D 1119; and,

A signal emerging at 1164 from the "AND-NOT" element 586, which is present only if B 1021 and S4 1108 are simultaneously present at the two energizing inputs and if D6 1165 does not constitute a prohibition. D6 results from the simultaneous application of D2 1101 and D4 1103 to the input of an "AND" element 587.

The means controlling unpacking in a case of burning and preburning 590 receives from the bath in question, by means of a call circuit, a burning signal AH via the lead 1038 or a preburning signal AJ via the lead 1037 or both signals simultaneously.

Each bath possesses a preburning relay which is energized by a volt rise appearing between the pilot anode and the cathode when the pilot anode is fed with a current density higher than the normal current density of the anodic system, and a burning relay which is energized by a volt rise appearing between the anodic system and the cathode. Once these relays are energized, they remain in action under the influence of the voltage normally existing at the terminals of the bath, and this goes on until a signal RZ returns them to zero.

Each preburning relay has a first contact which sends out a preburning signal AJ via the common lead **1037**, and a second contact which energizes the winding DPE **515** of the bath in question.

Each burning relay has a first contact which sends out a burning signal AH via the common lead **1038**; a second contact which energizes the winding DPE **515** of the bath in question; and a third contact which is cut when the relay is energized and which cuts the circuit feeding the winding DPE of all the preburning relays in the series of baths.

An "AND-NOT" element **592** is energized by the signal AJ but blocked by the signal AH. At **1040**, at the output of the element, the signal AJ appears provided that no AH signal is present. The signal is amplified in the amplifier **593**, which it leaves at **1041** in the form of a signal AJϕ of phase ϕ. Similarly the signal AH is amplified by an amplifier **594** which it leaves in the form of a signal AHθ of phase θ via the same lead **1041**. These three members **592**, **593** and **594** are disposed in a separate case connected to the memory proper by the one lead **1041**. It will be seen that in a case where two signals AJ and AH coming from two different baths arrive simultaneously at the input of **592**, priority would be given to unpacking after burning.

The signal conveyed by **1041** actuates in parallel both the burning memory **596** which responds only to signals of phase θ and the preburning memory **595** which responds only to signals of phase ϕ. **596** is also energized by the signal RMA via **1019**, whereas **595** is energized by a signal B or C which emerges at **1039** from an "OR" circuit **591**. The circuit **591** is actuated by the "program B" signal **1021** and by the "program C" signal **1022**. Both memories are also blocked by the signal MM **1024**. **595** supplies the signal J **1042**, and **596** the signal H **1043**.

The memory of unpacking after burning or preburning **600** comprises the memory of unpacking after burning **601** which records the signal H **1043** provided that the two signals RMA **1019** and $DPC \times DPE$ **1012** are present and the two signals $(DPA+R8)$ **1162** and K **1058** absent, the latter constituting the return signal, and negative conditions are transmitted by the "OR" circuit **602** to **1046**. Under these conditions, the memory **601** transmits a signal HE via the lead **1047**. It also comprises the memory of unpacking after preburning **603** which records the signal J **1042** provided that the two signals RMA **1019** and $DPC \times DPD \times DPE$ **1009** are present and the following signals absent: the signal H, lead **1043**, the prohibition signal transmitted to **1166** by the "OR" circuit **604** receiving $(DPA+R8)$ **1162**, K **1058** and a signal received by **1167** from the "AND-NOT" element **605** which is itself actuated by H **1043** and blocked by E4 **1144**. Under these conditions, the memory **603** transmits a signal JE via the lead **1049**.

The generator of the beginning of piercing impulse **610**, comprises the generator **611** which supplies the impulse L for piercing in front of an anode via **1050** and which is actuated both by a signal supplied at **1051** by the "AND" element **612** when its three inputs B **1021**, G **1032** and (D2 or D4) **1052** are actuated simultaneously, and by a signal P **1053** obtained in the "OR" circuit **613** when the latter is actuated by the signals GF **1036**, HE **1047** and JE **1049**. It also comprises the generators **614** and **615**, the impulses of which are transmitted via **1054** and **1055** to the "OR" circuit **616** which supplies the sum N thereof via **1056**. The generator **614** is actuated both by the signal P **1053** and by a signal P which only exists when P is absent, this signal being delayed relatively to P and emerging from an element **618** through **1163**. This generator is blocked by the signal emerging from **612**; the generator **615** is actuated by the signal DPA **1004**. It also comprises the "AND-NOT" element **617**, which is actuated by the signal GF or HE or JE **1053** blocked by the signal DPA **1004**, provides at **1057** the signal Q for maintaining the piercing action in front of an anode.

The memory **620** of the return of the carriage comprises the memory proper **621** which sends out at **1058** the signal K causing the rearward movement. The memory **621** is energized by the signal RMA **1019** and by a signal transmitted by the lead **1059**. It delivers the signal K only if both signals are present simultaneously. A prohibition signal is delivered by **1174**. It is supplied by the "AND" element **627**, the two inputs of which are actuated respectively by a delayed signal $\overline{DPA} \times DPB$ **1117** and by the signal TR **1172** described in connection with FIGURE 6. The lead **1059** serves as an output common to four blocks:

The "NOT" element **622** which releases a signal only if none of its five inputs is energized; the inputs are respectively actuated by the signals H **1043**, J **1042**, HE **1047**, JE **1049** and MM **1024**;

The element **623**, a simple coupling device which transmits the signal $DPA \times DPB$ **1014**;

The "AND-NOT" element **624** energized by a signal F3 **1062** from a bath counter F, which will be described hereinafter, and blocked by the signal G **1032**; and,

The "AND" element **625** which supplies a signal if its three inputs, which are respectively energized by the signals G **1032**, MM **1024** and a signal emerging via **1064** from an "AND" element **626**, are energized simultaneously; the element **626** is energized by a return signal V **1061** emanating from the register U, to be described later, and by the signal F **1163**.

The heart of the sequence control assembly is the piercing register **630**. The register is formed by a series connection of logical memories **631** to **642**. It enables the cycle of piercing at the head to be carried out by the action of the memories **631** to **638** and the cycle of piercing in front of the anode by the action of the memories **639** to **642**.

Each of these memories allows one of the above mentioned operations R1 to R12 to be carried out. Thus, the memory **631** carries out the operation R1, and the memory **640** the operation R10 and the memory **642** the operation R12.

By an information shunting process, one or other of the groups of memories **631** to **638** and **639** to **642**, respectively, is put into service.

Each memory comprises three energizing inputs and a blocking input and is released only on condition that the three energizing inputs are energized simultaneously and the blocking input receives no signal; it also comprises an output.

One of the energizing inputs of the memories **631** to **638** is energized by the signal P **1053** for maintaining piercing at the head, while the same input of the memories **639** to **642** is energized by the signal Q **1057** for maintaining piercing in front of the anode. The blocking input of each memory is actuated by the output signal of the following memory: thus the blocking input of the memory **634** is actuated by the signal R5 **1075** emanating from the memory **635**.

The two other energizing inputs of the memory **631** are actuated by the beginning of piercing signal N brought by **1056**. When the signals N and P are present simultaneously and the signal R2 **1072** absent, this memory supplies the signal R1 via the lead **1071**. The signal R1 causes the piercer to be translated to **14** and, by means of a temporization circuit, the crust to be pierced at this point.

The temporization circuit comprises an amplifier **649** which acts on a temporizer **650** via **1069**. The length of temporization of the latter is determined by the delay circuit **651** having a time constant RC3, connected by **1070**. The circuit **650** is blocked when it receives a signal via **1069**, emerging from the "NOT" amplifier **649**, which emits a signal only if none of its inputs is excited. It follows that so long as none of the signals R1 to R11 is applied to the amplifier **649**, the latter will emit a signal to block the temporizer **650**. When R1 is applied to one of the inputs of the amplifier via **1071**, the amplifier is blocked and there is no longer any signal acting on the temporizer **650**. After a period of time equal to the time constnt RC3 of the delay circuit **651**, the temporizer supplies a signal via **1083**. This signal, after passing into a circuit which will be described later and which permits manual control, becomes the signal E1 which is applied by the lead **1141** to the electric valve **332** actuating the piercing hammer.

All the following memories in the register advance by means of the lowered piercer signals as far as the even memories are concerned and raised piercer as far as the odd memories are concerned.

The raised piercer signal is the signal emerging from DPH via **1006**, whereas the lowered piercer signal may be either the signal emerging from DPI via **1007** or a piercing safeguard T4 which is substituted for DPI when the hammer fails after a given time to reach the low position detected by DPI. The signal T4 is obtained by means of a temporization system comprising an amplifier **652** which supplies a signal to the temporizer **653** via **1084** so long as its input is not blocked by the signal E1. The temporization of the member **653** is determined by the time constant $t_1=RC4$ of the delay circuit **654**. When the signal E1 is applied to the amplifier **652**, the temporizer is unblocked and, after a delay equal to RC4, supplies the signal T4 at **1086**.

The signal T4 actuates one of the inputs of the "OR" circuit **643**, the other input of which is actuated by the signal emanating via **1007** from DPI. At its output at **1065** the circuit **643** supplies a signal T4 or DPI which actuates the element **644**, the latter retaining only the first signal to arrive. This signal represents the lower position of hammer signal PIM which is applied by **1044** to one of the inputs of all the even memories.

The memory **632** is thus actuated by the signals PIM, R1 and P. When these signals exist simultaneously, the memory supplies, at **1075**, the signal R2 for the raising of the piercer. When this signal is applied to the memory **631**, it blocks the latter.

Similarly, the memory **633** is actuated by the signals DPH **1006**, R2 **1072** and P **1053**, if these three signals coexist, it supplies the signal R3 **1073** to block the memory **632**. The signal R3 is applied to and blocks the amplifier **649**, and the process is the same as for R1.

Of the following memories, the even memories are identical with **632** and the odd memories with **633**, as far as the memory **638**.

The memories **639** to **642** control piercing in front of an anode.

The memory **639**, which produces at **1079** the signal R9 controlling the translation of the piercer to **1** and piercing at this point, is energized by the signal Q **1057** for maintaining the piercing action in front of the anode (replacing the signal P **1053** of the preceding memories), DPH **1006** for the raised position of the piercer, and a third signal which is obtained at **1029** by applying the three following signals, which can only exist separately, to the "OR" circuit **648**:

The signal R8 **1078** emerging from **638**, present at the end of a piercing action at the head;

The signal L **1050** for the beginning of piercing in front of an anode, present when it is desired to pierce an anode without previously piercing at the head; and,

The signal T5 which is present when, after having pierced the points **1** and **2**, it is desired to pierce the following points **3** and **4** in front of the same anode. For this purpose the signal R12, which is delayed to permit translation of the carriage, acts on the memory **639**. The signal R12 **1082** blocks the amplifier **645** which, from that moment, transmits no more signals to the temporizer **646**, the temporization of which is determined by the time constant RC5 of the delay circuit **647**; when the signal R12 is applied to **1082** the temporizer is thus unblocked, and, after a time equal to RC5, supplies the signal T5 at **1067**. To arrest the piercing action at the end of a bath a signal **1087**, emanating from an "OR" circuit **655** actuated by the signal DPA **1004** and the signal R10 **1080**, is applied to a blocking input of the "NOT" circuit **656**, the other blocking input of which is connected to the output **1066** of the amplifier **645**. The circuit **656** is blocked only if its two inputs **1066** and **1087** are actuated simultaneously. In the absence of a signal R12 **1082**, **645** emits a signal whether or not **1088** is actuated. This signal actuates **656** via **1066**, but in the absence of a signal at **1087**, the current passes via **1088**. When R12 **1082** appears, the two inputs of **645** are actuated, there is no longer a signal at **1066**, and the temporizer is released. The disappearance of the actuation at **656** makes no difference. But if a signal DPA or R10 appears at **1087** before the appearance of R12 the circuit **656**, acted on at both blocking inputs, no longer releases any signal, the appearance of R12 no longer blocks **645** and T5 no longer appears at **1067**.

The memory **639** supplies the signal R9 **1079** which blocks the memory **638** and energizes the memory **640**. The memories of piercing in front of the anode are mounted from here, as explained in connection with the memories of piercing at the head.

The memory **642** is succeeded by the memory **639**, and it is thus the signal R9 **1079** which blocks **642**.

The counter F, reference **740** counts the number of baths while the counter D, reference **563** counts the number of runs. The counter F comprises the counter proper **741** which records a signal F only if its two inputs, actuated respectively by **1089** and **1090**, are energized simultaneously.

The counter **741** performs the following operations:

In the case of piercing C after burning or preburning, the counting of the baths unpacked; to this end the lead **1089** is connected to the output of the "OR" circuit **742** which supplies it with (HE or JE). The circuit **742** is thus actuated by HE **1047** and JE **1049**;

In the case of A piercing, the counting of the baths pierced; to this end the "AND" circuit **743** releases a signal at **1091** when its three inputs are acted on simultaneously by the signals DPA **1004**, A **1020** and G **1032**; and,

In the case of B piercing, the counting of the baths pierced; to this end the "AND" circuit **744** releases a signal **1092** when its three inputs are acted on simultaneously by the signals G **1032**, DPD **1002** and B **1021**.

The leads **1091** and **1092** each act on one of the two inputs of the "OR" circuit **745**, the output of which is connected to **1089**.

The other input of the counter **741** is connected by the lead **1090** first to the output of the "AND" circuit **748**, having two inputs of which one is actuated by the signal B **1021** and the other by the signal GE **1034**, and second to the output of the "NOT" circuit **746** which supplies a signal at its output provided that none of its three inputs is energized. The first of these inputs is actuated by the "rearward movement" signal MA **1093**. The second of the inputs receives the signal $\overline{DPA}\times DPB$ **1013**. The third input is connected by **1094** to the output of the "AND" circuit **747** having two inputs, one of which is energized by B **1021** and the other by MM **1024**.

The counter **741** supplies the following signals at the output, the number following the letter F indicating the number of baths counted: F1 1095, F2 1096, F3 1062, F4 1097 and F5 1098.

The coincidence circuit 660 emits a signal Γ each time the counters D and F display the same position. For this purpose the signals D1 1099 and F1 1095 are each applied to an input of an "AND" element 661 which releases a signal to the lead 1100 only if its two inputs are energized simultaneously. Similarly, D2 1101 and F2 1096 are each applied to an input of an "AND" element 662, the output of which is connected to 1102, whereas D4 1103 and F4 1097 reach the "AND" element 663 terminating at 1104. Moreover the signals D1 1099 and F1 1095 are applied to two prohibiting inputs of a "NOT" element 665 terminating at 1100. Similarly D2 1101 and F2 1096 are applied to 666 terminating at 1102, and D4 1103 and F4 1097 are applied to 667 terminating at 1104. The outputs 1100, 1102 and 1104 are each connected to one of the inputs of the "AND" element 664 which supplies an output signal Γ 1033 only if actuated simutlaneously at its three inputs. Thus, the existence of Γ translates the coincidence not only of the order signals 1, 2 and 4 but also of the order signals, 3, 5, 6 and 7.

The counter 670 of the number of pairs of holes pierced in front of an anode emits a signal S2 when four pairs of holes have been pierced, and after this signal another signal giving the order to feed the bath with alumina.

It comprises the pair counter 671 acted on by the signal R12 1082, which emits a signal S2 1105 when the signal R12 has been present four times. Across a separating amplifier 672 this signal is applied by 1106 to one of the two blocking inputs of the amplifier 673. It also actuates and blocks a temporizer 674 of which the temporization is determined by the time constant RC7 of the delay circuit 675 connected by 1107, the time constant being equal to the time which must elapse between the piercing of the eighth hole and the beginning of the process of discharging alumina. The signal emerging from 674 acts via 1108 on the second blocking input of the amplifier 673.

This amplifier acts via 1108 on the amplifier 676 having three blocking inputs and on the blocking input of the temporizer 677, the time constant RC2 of which is equal to the time during which alumina is discharged. The output of 677 acts on the second input of 676, the third input of which is connected via 1110 to a memory 679 which stores the signal DPF 1011.

The function of the return register U, reference 680 is to ensure that the apparatus returns to the head of the series to be refilled with alumina every time three baths have been pierced and fed. The number three is obviously arbitrary and any other number may be used, provided that the capacity of the hopper 410 and of the apparatus hereinafter described is suitably adapted.

The register U is similar to the piercing register 630. It comprises 13 memories 681 to 693. Each of the registers except for 681 is actuated by the signal emitted by the preceding register and, apart from 693, is reblocked by the signal emitted by the following register. Thus, the memory 682 is acted on by 1121, the output signal from the memory 681, and blocked by 1123 which conveys the output signal from the memory 683. All the memories are also actuated by a signal which is conveyed by 1119 and which exists only if the signals A 1020 and G 1032 are simultaneously present at the input of the "AND" amplifier 694.

Before the signals A and G are present, the "NOT" element 695 emits a signal through 1120, for it is not blocked by a signal transmitted by 1119; however, the memory 681 remains blocked since it does not receive the signal 1119. When the signal 1119 appears, the block 695, which is temporized, continues to emit its signal 1120 for a short time, the memory 681 is engaged.

The memory 682 is acted on by the signal F3 1062 which appears at the third bath pierced, and by the signal which emerges via 1121 from 681, it is thus coupled, and the signal U2 emitted by 1122 blocks 681. The signal U2 causes the carriage to return to the head of the series. As the signal U3, emitted into the lead 1123 by the memory 683, makes the carriage return to the fourth bath without proceeding to pierce the first three. This memory and the other memories of advance without piercing, namely 686, 689, and 692, will be actuated by the beginning of series signal, that is to say, $DPA \times DPB$, but retarded by the time taken to fill the hopper 410. For this purpose, the signal $\overline{DPA} \times DPB$ 1013 is applied to the blocking input of the amplifier 699 which in turn acts, via its blocking input, on the temporizer 700, the temporization of which is determined by the time constant RC6, reference 701, connected by 1118. In the absence of actuation at 1013 a signal emitted by 699 blocks the temporizer 700. At the appearance of the signal $\overline{DPA} \times DPB$ 699 is blocked, and the temporizer is unblocked after a time RC6. The delayed signal is transmitted by 1117.

The memories 685 and 687 are acted on by a signal F6 which is transmitted by 1113 and obtained by applying F2 1096 and F4 1097 to an "AND" element 696 which emits its signal only if the two input signals are present. Similarly, 688 and 690 are acted on by F9 which is obtained at 1114 by 697, in turn acted on by F8 1098 and F1 1095. Finally, 691 and 693 are acted on by F12 1115 which is emitted by 698, in turn acted on by F8 1098 and F4 1097.

At the output, the signals for the return to the head of the series U2 1122, U5 1125, U8 1128 and U11 1131 are applied to the "OR" element 702 which supplies a signal V at 1061 when at least one of its inputs is actuated. The signals for passage without piercing U3 1123, U6 1126, U9 1129 and U12 1132 are similarily applied to the "OR" element 703 which emits a signal W 1119.

If it is desired to refill the hopper every "x" baths pierced, it is sufficient to alter the number of groups of three memories accordingly and to use signals such as F_x F_{2x} F_{3x} etc., for actuating each group in the place of F3 1062, F6 1113, F9 1114, etc.

The means controlling the electric valves and translatory motors, reference 710, supplies the signals E1 to E5 which act, by means of amplifiers (not shown), on the electric valves 332, 333, 423, 362 and 363, respectively, and the signals MAV, MAR, GV acting on the relays (not shown) which control the following operation of the translatory motor:

Starting in forward direction: MAV 1140;
Starting in backward direction: MAR 1093;
Movement at high speed: GV 1146; and,

Movement at low speed corresponds to the state of rest of the latter relay.

Finally, the means 710 also supplies a signal RZ 1147 which returns the unpacking summons relays to zero.

These signals may also be obtained either by the automatic apparatus described above, or, when the switch 552 supplies the signal RMM via 1018 in the manual position, by manual controls with the aid of the following switches:

735 to 739 for the signals E1 1141 to E5 1145, respectively;

740 for the forward movement of motor translating the carriage, signal MAV 1140; and,

734 for the backward movement of the motor, signal MAR 1093.

The signal E1 is emitted at 1141 by the "OR" circuit 711 which receives the signal transmitted by the manual control 735 at 1135 and the signals T3 at 1083.

The signals E2 1142, E4 1144 and E5 1145 are supplied respectively by the "OR" circuits 712, 713 and 714. Each of these circuits receives at one of its inputs the signal emitted by the respective manual controls 736 via 1136, 738 via 1138 and 739 via 1139, the other inputs receiving combinations of the signals R1 to R10 obtained as follows:

R1 1071 and R2 1072 actuate the two inputs of the "OR" circuit 715 supplying (R1 or R2) at 1148;

R3 **1073** and R4 **1074** similarly actuate the "OR" circuit **716** supplying (R3 or R4) at **1149**;

R5 **1075** and R6 **1076** actuate the "OR" circuit **717** supplying (R5 or R6) at **1150**;

R7 **1077** and R8 **1078** actuate the "OR" circuit **718** supplying (R7 or R8) at **1151**;

R9 **1079** and R10 **180** actuate the "OR" circuit **719** supplying (R9 or R19) at **1161**;

The signals (R1 or R2) via **1148** and (R3 or R4) via **1149** actuate the "OR" circuit **720** supplying (R1 or R2 or R3 or R4) at **1152**; and,

The signals (R5 or R6) via **1150** and (R7 or R8) via **1151** actuate the "OR" circuit **721** supplying (R5 or R6 or R7 or R8) at **1153**.

The "OR" circuit **712** has its three last inputs connected respectively to **1148**, **1150** and **1161**. The "OR" circuit **713** has one of its two last inputs connected to **1153** and the other to **1152**, while **714** has its second input connected to **1152**.

The "OR" circuit **733** supplying the signal E3 at **1143** is actuated first by **1137** emanating from the manual control **737** and second by the signal T2 **1112**.

In this way, with automatic control, the appearance of the signal T2 releases E3 and that of T3 releases E1. The appearance of one of the signals R1, R2, R5, R6, R9 or R10 releases E2, whereas the appearance of one of the signals R1 to R8 releases E4 and that of one of the signals R1 to R4 causes the appearance of E5.

The signal MAV is emitted at **1140** either by the manual control **740** or by the "AND" element **726** comprising three inputs, simultaneous energization of which causes MAV to appear. The first input is connected to **1006** and receives the signal DPH. Another input is connected by **1155** to the output of the "OR" circuit **725**, of which the two inputs receive respectively **1032**, conveying the signal G, and **1134**, the output of the "OR" circuit **723** acted on by H **1043** and J **1042**. **1155** thus transmits a signal (G or H or J). The third input of **726** is connected to the element **724** which emits a signal via **1160** provided that one of its four blocking inputs is energized. Of these inputs the first is connected to R11 **1081**, the second to (R5 or R6 or R7 or R8) by **1153**, the third to (R1 or R2 or R3 or R4) by **1152** and finally, the fourth by **1154** to the output of the "OR" circuit **722**, the two inputs of which are respectively connected to K **1058** and to (R9 or R10), lead **1161**.

Thus the signal MAV is supplied at **1140** if the three following conditions are fulfilled simultaneously:

Presence of DPH at **1006**;
Presence of at least one of the signals G, H or J at **1155**; and
Absence of all signals R1 to R22 (but not R12) and of K.

The backward movement signal MAR is supplied at **1093** by the "AND" amplifier **729** provided that the two inputs of the latter are energized simultaneously. One of these inputs is connected by **1157** to the output of the "OR" circuit **727**, one of the inputs of which is connected by **1156** to the manual control **734** and the other by **1058** to the signal K. The other input of **729** is connected by **1158** to the circuit **728** having only one blocked input which is acted on by the signal $DPA \times DPB$ **1013**.

The signal MAR **1093** is emitted, during automatic operation, provided that the two following conditions are fulfilled simultaneously:

Existence of K **1958**; and,
Absence of $DPA \times DPB$ **1013**, constituting the signal for starting at the beginning of the series.

The signal GV which sets the motor for translating the carriage to high speed emerges via **1146** from the element **731** comprising two inputs of which one is a blocking input. The normal input receives the lead **1134** conveying (H or J), while the blocked input is connected by **1159** to the output of the "OR" circuit **730** of which the four inputs receive, respectively, the following prohibition signals:

Via **1093** the signal MAR;
Via **1047** the signal HE;
Via **1049** the signal JE; and,
Via **1015** the signal DPE.

The signal GV is thus present at **1146** provided that the two following conditions are fulfilled simultaneously:

Presence of (H or J) **1134**; and,
Absence of the four prohibiting signals, the presence of any one of these signals blocking **731**.

The signal RZ is supplied at **1147** by the "OR" circuit **732**, of which one of the inputs receives HE via **1047** and the other JE via **1049**.

The manner in which the apparatus functions will now be explained.

It will be recalled that the carriage may be positioned as follows, resulting from the following logical combinations between the indications of the proximity detectors DP:

$\overline{DPA} \times DPB$, that is to say, DPB energized, DPA not energized, corresponds to the position of the carriage at the head of the series;
DPA energized, the carriage is in position for piercing at the head at the end of a bath;
$DPA \times DPB$, both energized, signify that the carriage is at the end of the series;
$DPC \times DPD$, both energized, the carriage is in position in front of a bath ready to start piercing;
$DPC \times DPD \times DPE$, all energized, the carriage is in position for piercing after preburning;
DPD energized indicates that the carriage is in front of an anode, in position to pierce it;
DPH energized, the piercing hammer is in the raised position;
DPI energized, the piercing hammer is in the lowered position; and,
DPF energized, alumina must not be discharged onto the bath.

Program A.—Noncontinuous piercing

One of the machines pierces each bath completely, and every X (for example three) baths it returns to the head of the series to restock with alumina. The other machine pierces baths which are in a state of "burning" and responds only to "burning" summons. After a certain number of hours (six in the example described) the functions of the two machines are reversed.

The logical circuits are live as soon as the general disconnecting switch is engaged. But, as the relay **551** is not thereby engaged, no manipulating of members is possible, for there is no voltage present either in the amplifiers of the electric valves or in the coils of the contactors of the carriage motor.

The first of the machines used starts noncontinuous piercing, which makes it possible to choose which side of the baths is to be pierced first. The second machine remains waiting for burning summons.

The switch **552** is in the automatic position with the lower contact made, and **553** is in position A with the upper contact made. The machine is at the head of the series and there exists the logical combination:

$$\overline{DPA} \times DPB = 1$$

The operator engages the relay **551**, which results in the energizing of the amplifiers of the electric valves; and, the appearance of the signal A at **1020** and the signal (A or B) at **1023**.

The "AND" element **555** thus has both inputs energized, one by (A or B) at **1023**, the other by $DPA \times DPB$ at **1013**. It therefore supplies a signal MM at **1024**. This signal acts on the element **555** which supplies the signal

RMP1 at **1025**, and this engages the relay **561** controlling the time switch **562**.

The time switch **562** supplies impulses MN **1027** at regular intervals (for example hourly), and these are stored in the run counter D **563**.

It will be noted that, as a result of the delay brought about by the element **556** and by the time taken to engage the time switch and its controlling relay, there is a lag between the appearance of the signal MM **1024** and the energizing of the time switch. When the latter is live, the signal MN dissappears. This delay is sufficient to actuate the piercing memory **573**. The starting condition, i.e., $\overline{DPA} \times DPB$ **1013**, is present

In program A, the signal MN **1024** will be used only once to actuate **573**. In the "AND-NOT" element **572**, we in fact find the operating conditions $\overline{DPA} \times DPB$ and MN, but also a blocking signal at **1030**. This signal has come from a memory **571** which is actuated by the operating cycle, i.e., by R1 **1071** and uncoupled by D7 **1028**, the seventh pip of the time switch recorded in the counter D. Thus, the other pips MN have no effect on the piercing memory but are recorded in the counter D up to the seventh. When the signal D7 appears, the two machines are changed over.

Once the piercing memory has been actuated, the signal G **1032** appears, with the result that the carriage is started at low speed in a forward direction, and G is in fact present at the input of **725**, **726** supplies a signal, for the three conditions of intake are fulfilled:

DPH, the piercer is in the raised position;

724 emits a signal, for none of the piercing subcycles R represented by **1071** to **1081** has started; and,

725 transmits the signal G.

The signal MAV is thus transmitted by **1140** to the relay controlling the motor.

The carriage advances, meets the sensitizing plates of the proximity detectors, and the combination:

$$DPC \times DPD = 1$$

appears. This causes the memories **581** and **583** to be actuated in that order. The signal GF appears at **1036**.

The effect of GF is to produce an impulse N for the beginning of piercing at the head **1056**, emerging from **614**. The "OR" circuit **613** in fact transmits GF by **1053** to **614**, and no signal appears at the blocking input **1051** because of the absence of B **1021** from the input of the "AND" element **612**.

The signal N **1056** actuates the input memory **631** of the piercing register **630**. The signal P is in fact present, having emerged from the "OR" circuit **613** acted on by GF. The signal R1 **1071** therefore appears, but comes as a prohibition to **724**, blocking **726**. The signal MAV disappears and the carriage stops.

The cycle of piercing at the head takes its course with the successive actuation of the memories **631** to **638**. The register advances by means of the signals DPH **1006**, piercer raised, and DPI **1007**, piercer lowered. In the case of the piercer not succeeding in piercing the crust completely, a piercing safety signal T4 is substituted for DPI. T4 is obtained by delaying the signal E1 controlling the electric valve **332** by the action of the temporizer **653**, the temporization of which is determined by the delay circuit **654**. The signal P **1053**, maintaining piercing at the head, is present in these first eight memories. Each memory is also actuated by the preceding memory and blocked by the succeeding memory. The signals R1 **1071** to R8 **1078** are thus obtained successively in a rhythm fixed by DPH on the one hand and DPI or T4 on the other.

The electric valve **332** of the piercing hammer is acted on by odd R signals R1 to R11. In the absence of such a signal, the prohibiting amplifier **649** emits a signal through **1069** to block the temporizer **650**, and no signal is transmitted via **1083**. Conversely when an odd R is emitted, **649** is blocked, the prohibition transmitted by **1069** no longer exists and, after a time RC3 fixed by **651**, the signal T3 **1083** is transmitted. It acts on the "OR" circuit **711** which emits the signal E1 **1141**. This acts on the electric valve **352**, thus causing the piercer to move downwardly and, as soon as resistance to this movement makes itself felt, piercing takes place. Piercing continues until either the signal DPI intervenes or, if this signal has not been emitted after a time RC4 **654** after the emission of E1, the signal T4 **1086**. The signal (DPI or T4) leaving the "OR" circuit **643** is in fact the signal **1044** for the lower position of the hammer. In the presence of the preceding (even) R signal and of the signal for maintaining the piercing action P **1053**, this signal **1044** releases the following memory so that the following (odd) R signal is emitted.

The signals R1 to R8 thus cause the points **14**, **13**, **12** and **11** to be pierced.

Thus, when R1 is sent by **1071** E2, emitted at **1142** across **715** and **712**, energizes the electric valve **333**, E4, emitted at **1144** across **715**, **720** and **713**, energizes the electric valve **362** and E5, emitted at **1145** across **715**, **720** and **714** energizes the electric valve **363**. The hammer comes into the completely forward position, and piercing commences by means of **649** and **650** after a time RC3 corresponding to the forward movement of the piercer.

When DPI is energized or, failing that, after a time RC4 **654** the memory **632** is energized, **1044**, **1071** and **1053** being energized simultaneously and the signal R2 is emitted, it blocks the memory **631** thus stopping the emission of R1. The prohibiting amplifier **649** is no longer energized and emits a signal via **1069** to block **650**. The signal T3 **1083** is stopped, thus stopping E1 **1141**. The electric valve **332** is no longer energized, and the hammer rises and DPH **1006** is present so that memory **633** is energized, **632** is blocked, and the signal R3 **1073** appears. By the action of the circuits of **710**, the signal E2 **1142** is cut out, but E4 **1144** and E5 **1145** remain present. The piercer is in front of the point **13** and, as **649** is energized, pierces it after a time RC3 **651**.

Piercing continues in a similar manner until the appearance of R8 **1078**, which returns the piercer to the raised position, and of DPH **1006**. R8 **1078**, acting across **648**, energizes the memory **639** via **1029**, Q **1057** is in fact present for the signal DPA **1004**, which comes to **617** as a prohibition (see FIGURE 18) is absent. The memories **639** to **642** operate exactly like the preceding ones, the only difference being that the signal Q **1057** for maintaining piercing in front of the anode has been substituted for P **1053**, the signal for maintaining piercing at the head. The signals R9 to R11 are emitted and the points **1** and **2** pierced in turn.

During the work at the head and first piercing subcycle in front of the anode (points **1** and **2**) the machine remains immobile. The signals R1 to R11 in fact constitute a prohibition of **724**. No signal MAV **1140** is emitted. The emission of R12 **1082** normally causes the hammer to be raised by nonenergization of **649**. As soon as DPH **1006** is present, as the prohibition of R1 to R11 at **724** no longer exists, **726** is energized, G still existing, and the signal MAV **1140** reappears. The carriage sets off again and advances one step.

This step is defined by a time RC5, the time constant of the circuit **647**. R12 **1082** is applied as a prohibition to **645** which acts on the temporizer **646**, also as a prohibition. In the absence of R12 no signal appears at **1067**. At a time RC5 **647** after the appearance of R12 the signal T5 **1067** appears and actuates the memory **639**. R9 **1079** appears, uncouples **642** and blocks **724**. MAV **1140** disappears and the carriage stops. The sub-cycle of piercing in front of the anode is reproduced for points **3** and **4** as explained in connection with **1** and **2**.

This subcycle is repeated over the whole bath until the appearance of the end-of-bath signal DPA **1004** which, arriving as a prohibition at **617** (FIGURE 18), makes the signal Q **1057** disappear. The memories **639** to **642** can no longer be actuated. The signal DPA is moreover applied to the element **615** and makes the signal N **1056** reappear. This actuates the memory **631**, for P **1053**, which is GF **1036**, is still present. Piercing at the head at the end of the bath takes place as explained above.

When R8 appears, the work of piercing at the head is over. The machine has to move onto another bath. The simultaneous appearance of R8 **1078** and DPA **1004** results in the appearance at the output of the "AND" element **584** at **1162–1171** of a signal $(DPA+R8)$ which blocks **583**, thus cutting off the signal GF **1036** and consequently P **1053**. As **724** is no longer blocked and G **1032** and DPH **1006** are still present, the signal MAV **1140** reappears and the machine advances at low speed, for DPE is blocking **731**.

The counter F **741** records a pierced bath. The element **743**, simultaneously energized by DPA **1004**, A **1020** and G **1032**, records the digit F1 **1095**.

The second and third baths are pierced like the first. At the end of the third bath DPA **1004** makes the digit F3 **1062** appear at the output of **741**.

The register of returns **680** has its register U1 **681** actuated from the start. When F3 **1062** appears the register **682** is actuated in turn. It emits the signal U2 **1122** which blocks the memory **681** and actuates the return memory **621** by means of the elements **625** and **626**.

Two conditions are required at **626**:

The presence of V **1061**, resulting from the transmission of U2 **1122** by the "OR" circuit **702**; and,

The presence of $\overline{P}=\overline{GF}$ **1163**, indicating that GF is eliminated since piercing is over.

The signal K appears at the output of **621**, **1058**. It appears both as a prohibition at **724**, thus stopping MAV **1140**; and at **729**, by means of the "OR" circuit **729**, where it produces the signal MAR **1093**. Acting on the relay controlling the motor of the carriage, this signal starts the carriage in a backward direction. **728** supplies a signal via **1158**, for $\overline{DPA}\times DPB=0$.

It will be noted that the combination $DPC\times DPD$ appears on the return journey but that it has no effect on the piercing memories since K **1058**, by means of **585**, comes as a prohibition to **583** and **581**. GE **1034** and GF **1036** are absent.

Withdrawal of the carriage also gives rise to DPA, which could advance the counter F **740**, so the signal MAR **1093** comes as a prohibition to **746**, thus blocking the counter **741**.

Conversely, during the backward movement just as the forward movement, the counter D **563** records the number of impulses MN **1027** emerging from the time switch **562**.

When the carriage arrives at the head of the series, the signal $\overline{DPA}\times DPB=1$ appears; **729** is blocked by means of **728** and the signal MAR disappears; and the backward movement relay drops and the carriage stops.

The signal $(\overline{DPA}\times DPB)$ delayed from R6 by the circuits **699**, **700** and **701** then appears at **1117**. This signal constitutes a prohibition at **621**, and the signal K **1058** therefore disappears. On the other hand, it actuates the memory **683** which supplies the signal U3 **1123**. Across **703** the signal U3 becomes W **1119**, the signal for advance without piercing, which comes as a prohibition to **581** and **583** and prevents GE **1034** and GF **1036** from appearing when the combination $DPC\times DPE$ is present at **1008**. The counter F **740** records the number of times the carriage passes at DPA **1004**; F3 appears at **1062** and is applied to the input of **684**; and a signal appears at **1124** and blocks **663**, causing W **1119** to disappear. From that time on, as soon as the combination $DPC\times DPD$ **1008** appears, the memories **581** and **583** are actuated again triggering off the piercing process. The fourth, fifth and sixth baths are then pierced.

After the piercing of the sixth bath, F2 **1096** and F4 **1097** cause the signal F6 **1113** to appear at the output of **696**. This actuates **685** and thus U5 **1125** and, across **702**, the return signal V **1061**. After the return, the delayed signal $\overline{DPA}\times DPB$ **1117** actuates **686**, which emits U6 **1126**. This results in the signal W **1119** for advance without piercing and the energization of **687**, which blocks **686**, thus allowing the baths **7**, **8**, **9** to be pierced.

For the ninth bath, the following memories are used:

686 giving U8 **1128** for the return to the head of the series;

689 giving U9 **1129** for the advance without piercing;

690 blocking **689** for the piercing of the baths **10**, **11** and **12**.

For the twelfth bath the memories are as follows:

691 giving U11 **1131** for the return to the head of the series;

692 giving U12 **1132** for the advance without piercing; and,

693 blocking **692** for the piercing of baths **13**, **14** and **15**.

When the fifteenth bath is pierced, the return memory **620** is actuated by the signal $DPA\times DPB$ **1014** (the two detectors being energized at the same time) by means of the element **623**, and the carriage retreats backwards at low speed. The piercing memory **570** is uncoupled by the same signal $DPA\times DPB$ **1014**, applied as a prohibition at **573**, and the signal G **1032** disappears. Once it arrives at the head of the series the carriage cannot set out again and remains in the waiting position.

The discharge of alumina onto the baths is carried out as follows. Each time the signal R12 **1082** is emitted by the memory **642**, the counter of the number of pairs of holes pierced, or counter S, reference **670**, stores a digit representing the piercing of two holes. The function of the counter in the three programs A, B, and C is to initiate an alumina discharging process every eight holes. In the absence of S2 **1105**, the alumina temporizer **674**, of which the temporization RC7 (the time elapsing before the discharge of the alumina) is determined by **675**, discharges into **1108**, blocking **673**. The temporizer **677**, of which the temporization RC2 (time taken to discharge alumina) is determined by **678**, thus discharges into **676**, blocking this amplifier. No signal is present at **1112**. When the fourth signal R12 appears at **1082**, the counter emits the signal S2 **1105** which blocks the temporizer **674** after a time RC7. From then on, the amplifier **673** emits the signal S4 **1108** which blocks **677** for a time RC2. The amplifier **676** emits a signal T2 **1112** of a duration equal to RC2. The nonfeeding signal DPF, stored by **679**, comes as a prohibition to **676** and prevents discharge if it is present.

After passing into **733** the signal T2 becomes E3 and is applied to the electric valve **423**.

Program B.—Continuous piercing

One of the machines carries out a piercing cycle over each bath boring a certain number of holes, for example eight, in front of an anode. The anodes are pierced in order from the first to the last, i.e., from 1 to 6 in the example in question. When one anode in each bath has been pierced, the carriage returns to the head of the series and awaits an order from the time switch for starting again. The other machine carries out "unpacking" operations and responds to summonses in cases of burning and preburning.

The logical circuits are live as soon as the general disconnecting switch is engaged, but no manipulation is possible so long as the relay **551** is not coupled.

The switch **552** is at "automatic," **553** is in the position B with the middle contact made, the machine is at the head of the series and $\overline{DPA}\times DPB=1$.

The operator engages the relay **551**, and the signal B appears at **1021** and the signal $(A+B)$ at **1023**. The latter signal acts as above to start the time switch and the counter records a first digit D1 at **1099**. The piercing memory is actuated and supplies G **1032** as above, but the prohibition is not present at **1030** since the block **571**, which is no longer energized by A **1020**, is not operating. Thus after a first run, the machine restarts following an order MN **1027** from the time switch **562** to go and pierce the second anode.

The counter **563** records a number of runs when all the anodes, here six, have been pierced. The digit D7 **1028** appears and the two machines exchange functions.

The signal G is thus present at **1032**. As in program A, it involves the presence of the signal MAV **1093** which causes the carriage to set off forwards at low speed. As the carriage advances, the combination $DPC \times DPD$ appears. The counter F **740** is actuated by **744**, where G **1032**, DPD **1002** and B **1021** are present, and causes F1 **1095** to appear while GE **1034** appears at the output.

The signals F1 and D1 are present simultaneously at the input of **661** A coincidence signal Γ appears at **1033**. Since D2 **1101** and F2 **1096** are both absent, **666** emits a signal at **1102** and the same applies to the signals D4, F4. The effect is to actuate the memory **583** which emits GF at **1036**. GF acts on **614** via **613** and hence N **1056** appears and initiates piercing at the head, P **1053** being present at **631**.

The impulse N for piercing at the head appears only in the first and last (here the sixth) run. In the last (here the sixth) run, it is produced not by GF **1036** but by DPA **1004**. In the element **612**, the output **1051** of which forms a prohibition at **614**, there are three conditions:

Program B **1021**;
A state of being pierced, G **1032**; and,
(D2 or D4), a signal produced in the "OR" circuit **565**, present in all runs except the first.

Thus N **1056** can appear only in the first run. In the last (here the sixth) run, it is created by **615** which is actuated by DPA **1004**.

Piercing at the head is carried out as in program A, and piercing in front of the anode follows but has to cease when eight holes have been bored. For this purpose, the counter S **670** has two functions. As in program A, it is responsible for the discharge of alumina, and it stops the piercing cycle at the eighth hole by means of the signal S4 **1108** which, across **585**, deactuates the memory **581** and makes GE **1034** disappear. The signal is applied by means of the element **586** which supplies a signal at **1164** only if its two inputs B **1021** and S4 **1108** are energized and if the blocking input, acted on by D6 **1165**, is not energized. S4 acts thus only in program B and not in the sixth run. D6 is obtained from the element **587** which supplies it only if simultaneously energized by D2 **1101** and D4 **1103**. Prohibition in the sixth run is due to the fact that piercing at the head must occur in this run.

After piercing the first anode in the first bath, the machine resumes its forward movement, G **1032** still being present, and arrives at the second bath. The combination $DPC \times DPD$ appears and has the same effect as above. F1 **1095** appears, there is coincidence between F1 and D1 **1099** and **1033** appears at the output of **664**. The same process takes place over each bath.

When the carriage reaches the end of the series, the signal $DPA \times DPB = 1$ appears, deactuates the piercing memory **570**, and actuates the return memory **620** which emits the signal K **1058**. The carriage returns to the head of the series, moving backwards at low speed. When it arrives at its destination, the condition $\overline{DPA} \times DPB$ **1013** appears, stopping the carriage **728**, and the delayed signal $DPA \times DPB$ **1117** deactuates the memory **620**.

The carriage is therefore at the head of the series, ready for the second run. When the time switch sends out impulse MN **1027**, the latter actuates **572**. G **1032** appears and starts off the carriage in the forward direction at low speed. N **1056** does not appear. In fact, D2 appears at (D2 or D4), lead **1052**, with G **1032** and B **1021**, so that a prohibtion signal is present at **1051** on **614**.

The machine arrives in front of $DPC \times DPD$, and the memory **581** is actuated and supplies GE **1034**. The counter **566** displays D2, and the counter **741** records the number of passages over DPD. When F2 appears, **662** is energized by the simultaneous presence of D2 and F2, and **1033** appears and actuates the memory of effective piercing **580**. GF **1036** appears and creates in **611** an impulse L **1050** which initiates piercing in front of the anode by acting on the memory **639** across the "OR" circuit **648**. R9 **1079** appears and arrests the movement of the machines, and the piercing cycle starts as explained above.

The piercing of the anode stops on the appearance of S4 **1108** which deactuates the memories **581** and **583** via **586**. GF **1036** disappears and the piercing record is returned to zero as a result of the disappearance of the maintaining signal Q **1057**.

The machine sets off again in a forward direction to pierce the second anode in the following bath.

The register for return after every three baths **680** does not operate since the signal A **1020** is absent from the input of **694**. The following runs, up to the last but one (here the third, fourth and fifth runs) are identical with the preceding one.

The last run (here the sixth) starts following the order from the time switch given by the signal MN **1027**. As for the other runs, piercing starts when the signal Γ **1033** is emitted, indicating that there is coincidence between the number of runs and the number of baths, i.e., of anodes pierced, that is to say, coincidence between D6 and F6 or, and this is equivalent, between D2 and F2 and between D4 and F4. By means of the signal L **1050**, the machine starts a piercing operation in front of the anode. S4 **1108** cannot intervene at **586** for D6 **1165** forms a prohibition. It is thus DPA **1004** which, by its action on **605**, initiates piercing at the head as with the other piercing by creating the impulse N **1056** and uncoupling the record of piercing in front of the anode, references **639** to **642** by eliminating the maintenance signal Q **1057**. At the end of the piercing operation, R8 **1078** and DPA **1004** are present at **584** and uncouple the memories **581** and **583**. The disappearance of GF **1036** which is identical with P **1053**, a condition of maintaining the process of piercing at the head, causes the corresponding memories to be uncoupled, and work ceases.

The carriage sets off forwards at low speed until it meets the combination $DPA \times DPB$ **1014** which actuates the return memory **621** by means of **623**. The carriage sets off again in a backward direction at low speed until $\overline{DPA} \times DPB$ **1013** appears. This stops the movement and after having been delayed at **700**, lead **1117** uncouples the return memory **621**.

The machine waits, and at the seventh pip of the time switch, D7 appears and reverses the roles of the two machines.

It will be noted that seven pips are stored, but that they correspond to six runs, since the first pip is recorded at the time 0 at the beginning.

Program C.—"Unpacking" in cases of "burning" and "preburning"

Once the master relay **551** is engaged, the two machines are in the waiting position, ready to go to baths in a state of burning or preburning.

After completely piercing the bath, the machine returns to the starting point either if no further summons upstream has been received or if a certain number of baths, here three, have been unpacked consecutively in order to relead the alumina capacity. If a summons has been received during the piercing operation the machine continues its journey to explore the baths downstream. Displacements are made in a forward direction at high speed and piercing at low speed.

The switches **552** and **553** are in the "automatic" position **1019** and the "program C" position **1022** respectively. The operator engages the relay **551** which energizes the power amplifiers acting on the electric valves and the relays of the motor. The time switch is not set in motion for the signal (A or B), lead 1023, is not in existence.

Each bath has a burning relay and a preburning relay (not shown). The latter relay can be energized if the liquor contains a variable predetermined amount of dissolved alumina such as the minimum content defined above or slightly less. Each bath also has a winding E 524 adapted to energize the proximity detector DPE 515 of the carriage. The relays have a second contact. The second contact of all the preburning relays in the series is connected to the lead 1037 into which it sends a signal AJ, while that of all the burning relays is connected to the lead 1038 into which it sends a signal AH. Thus there is both a coil signal AJ or AH which is not differentiated as far as the bath is concerned and which serves to "alert" the machine, and also a signal for identifying the bath by means of the coil 524, which serves to stop the carriage over the bath in a state of burning or preburning. As explained above, each burning relay also has an extra contact which, when the relay is energized, cuts off the supply from the circuit feeding the windings E of all the preburning relays. Thus, so long as a burning relay remains energized, the carriage stops only in front of the burning baths to the exclusion of the preburning ones.

If a preburning signal AJ is sent out in the absence of a burning signal AH, the signal AJ 1037 acts on the "AND-NOT" element 592 and, via 1040, actuates the amplifier 593 which it leaves via 1041 in the form of a signal AJϕ of phase ϕ.

If a burning signal AH 1038 is sent out, it acts as a prohibition to the element 592, thus preventing any action on the part of a preburning signal AJ which could have been sent out approximately simultaneously. It is also applied via 1038 to the amplifier 594 which it leaves via 1041 in the form of a signal AHθ of phase θ.

The lead 1041, conveying the two signals of different phase, acts in parallel on the two memories 596, generating the signal H 1043, which responds only to signals of phase θ, and 595, generating the signal J 1042, which responds only to signals of phase ϕ. The signals C 1022 and B 1021 are also present at 595 and RMA 1019 is present at 596. Thus, the preburning signal J is formed only in programs B and C whereas the burning signal H is formed in all three programs. Both memories are blocked by MN 1024 emerging from the time switch 562 which does not operate in program C.

In the case of a summons for burning, the presence of H 1043 at 723, 725 and 726 causes the carriage to start off in a forward direction but at high speed, for (J or H), lead 1134, is also present at 731. The carriage sets off for the burning bath.

The signal DPE 1003 appears first, and it is memorized in 541. The signal emerging from this memory at 1015 appears as a prohibition at 731. The high speed relay drops off, and the carriage begins piercing at low speed.

The memorizing of DPE causes the combination $DPC \times DPE$ 1012 to appear and actuate the memory of the "unpacking after burning" summons 601 which emits the signal HE 1047. The signal actuates 614 via 613, and 614 emits the signal N 1056 for piercing at the head. The operations then take place as for program A, the signal HE replacing GE.

When the burning of this bath is eliminated, if a burning summons is still present, the conditions are the same as at the beginning. The carriage leaves in a forward direction at high speed to explore the baths downstream. If there is no summons, the return memory 621 is actuated, for there is no longer any prohibition at 622. The carriage returns to the starting point.

If a burning summons is received during the return journey, it does not uncouple the return memory and the carriage returns to the head of the series.

The memory 621 is uncoupled by delayed $\overline{DPA} \times DPB$ 1117. If the summons is present the carriage sets off again immediately as before.

In the case of a summons for preburning, the presence of J 1042 at 726 and 731 causes the carriage to start in a forward direction at high speed. The signal DPE 1003 appears, is memorized in 541, which blocks 731 and makes the high speed relay drop out. The carriage returns to low speed for piercing purposes.

The signal $(DPC+DPD+DPE)$ 1009 actuates the memory 603 which emits JE 1049. The presence of this signal has the same effects as that of HE and the cycle takes place in an identical manner. The returns also take place under the same conditions.

If burning is eliminated successively over several baths on an outward run, the number of times that HE or JE have been actuated is recorded by the counter F 741, which is actuated by these signals by means of 742. When three baths have been unpacked, the digit F3 appears at 1062 and actuates the return memory 621 by means of 624. After the time RC 6 required for discharging alumina, the delayed signal $\overline{DPA} \times DPB$ 1117 uncouples 621. The signal K 1058, present at 1154 over 724, prohibits any movement.

It will be noted that the preburning memory is uncoupled by the signal 1166 emerging from 604. Apart from the coexistent signals K 1058 and $DPA \div R8$ 1162, this represents the signal 1167 which emerges from 605 and which exists only if H 1043, i.e., a burning summons, is present and if E4 1144 is absent. The latter signal is present during the whole operation of piercing at the head, i.e., during the subcycles R1 to R8. This supplementary condition makes it possible for the piercing operation to be terminated, if a burning summons is received during the piercing at the head, thus enabling the hammer to be released. Once the piercer is released, the carriage sets off at high speed in a forward direction to go to the burning bath at which it carries out a complete piercing operation.

The roles of the two machines are reversed as follows (FIGURE 12).

The two machines are similar. They are in the same logical conditions and the switch 553 is in the program A position.

The machine which is started first by the action of 551 carries out a continuous piercing operation, while a blocking action causes the second to respond only to burning summonses.

In order to bring about these conditions, a reciprocal blocking signal M1 is conveyed by the lead 1168 passing from one machine to the other.

The first machine to be engaged sees the signal (A or B), lead 1170, act on the "AND-NOT" element 557. In the absence of prohibiting signals at 1169, the element 557 emits a signal (A or B) via 1023, to which the element 559 gives a phase ϕ. A signal N1 ϕ is thus transmitted as a prohibition to 557 of the other carriage and blocks the signal (A or B), for 557 of the other carriage responds to a signal of phase ϕ. This prevents the other machine from doing continuous piercing but not from responding to burning summons, since MM 1024 is not present therein as a prohibition at 596. The signal M1 ϕ does not act on 557, which can be blocked only by a signal of phase θ emitted by the machine.

When D7 appears in the first machine 557 is blocked and MM and consequently M1ϕ disappears. The prohibition in the second machine is removed, the signal MM appears, the time switch is energized and the piercing memory is actuated, and the machine leaves for continuous piercing. The prohibition M2 of phase θ, coming from the second machine, is substituted in the first machine for D7, which has disappeared, and prohibits 557 and consequently MM.

It will be noted that, thanks to the switch 552, the machine can be set to manual control by means of the signal RMM from 1018. The contactors 735 to 740 then allow the various members of the carriage to be controlled directly.

The operation of refilling the hopper **410** with alumina at the head of the series is carried out as follows. When the carriage arrives at its filling position, the relay **444** is energized by the plate **443**. As the hopper **410** is not full, the means **414** do not function and the relay **441** does not energize the detector DPI **443** by means of the winding **442**. The relay **445** remains at rest and the circuit feeding the relay **446** stays closed. The electric valve for discharging alumina is actuated by **1173** and opens.

When the hopper **410** is sufficiently full the means **414** actuate the relay **441**. The winding *DPE*×442 is energized and the relay **445** fed, thus breaking the circuit of relay **446**. The electric valve is closed again, cutting off the supply.

During the filling operation, no signal is transmitted by **1172**. The "AND" element **627** does not supply any blocking signal to the memory **621**. The signal K **1058** remains, preventing the carriage from being started. When filling is over, **627** has both inputs fed. It consequently blocks the memory **621** and eliminates the signal K, thus permitting the carriage to move forward.

It will be understood that changes may be made in the details of construction and operation without departing from the spirit of the invention, especially as defined in the following claims.

I claim:

1. A machine for piercing and introducing feed material into molten baths having crusts on the surfaces thereof comprising a carriage, means for displacement of the carriage to positions along the front of the molten bath, a piercing hammer mounted on the carriage for vertical movement in the direction toward and away from the surface of the bath between raised and lowered positions, means responsive to the resistance to penetration of the hammer through the crust on the bath for initiation of operation of the hammer to form an opening through the crust, a hopper mounted on the carriage for the feed material, means adapted to discharge feed material from the hopper into the openings formed through the crust, and a sequencing and control means adapted to be responsive to the position of the carriage relative to the bath and the position of the piercing hammer between raised and lowered positions to:

(1) displace the machine until it is in front of the bath to be fed;

(2) lower the piercing hammer to lowered position to provide an opening through the crust on the bath;

(3) displace the machine a short distance along the bath as the piercing hammer has completed its penetration through the crust on the bath and is returned towards raised position;

(4) pierce the bath again and continue the operation of steps (2) and (3) until a number of aligned openings have been provided through the crust on the bath;

(5) deposit feed material from the hopper onto the bath after the piercing operations have been completed, and

(6) displace the machine back to its starting position after the essential constituents of the bath have been brought to their desired concentration.

2. A machine as claimed in claim **1** which includes a silo in starting position for storage of large amounts of feed material and means adapted to sequence the filling the hopper with feed material while the machine is in starting position.

3. A machine for feeding powdered alumina into molten baths having a crust on the surfaces thereof and through which anodess extend into the baths for the production of aluminum by electrolysis and in which a plurality of such baths are aligned in spaced apart relation comprising a carriage, means for displacement of the carriage from starting position to a position along the fronts of the baths, a piercing hammer mounted on the carriage for vertical displacement between raised and lowered positions, means adapted in response to resistance to penetration of the hammer through the surface of the bath during displacement to lowered position for initiation of the operation of the piercing hammer to form an opening into the crust, a hopper on the carriage for the storage of alumina, means for discharging alumina from the hopper onto the molten bath in the portions pierced by the hammer, and sequencing and control means responsive to the position of the carriage relative to the baths and responsive to the position of the piercing hammer between raised and lowered positions adapted to:

(1) displace the carriage to a position in front of the anode of the bath to be fed;

(2) lower the piercing hammer responsive to positioning of the carriage to pierce the crust and form an opening in the surface of the bath;

(3) raise the piercing hammer from the bath;

(4) displace the carriage a short distance responsive to displacement of the hammer towards raised position;

(5) pierce the bath again and repeat steps (2), (3) and (4) until a number of openings have been provided in the surface of the bath;

(6) feed alumina from the hopper onto the surface of the bath responsive to completion of the piercing operation, and

(7) displace the machine to starting position.

4. A machine as claimed in claim **3** which includes a silo for the storage of alumina in starting position.

5. A machine as claimed in claim **3** in which the means for displacement of the carriage is operated by a fluid drive.

6. A machine as claimed in claim **3** which includes pressure fluid means for operation of the hammer.

7. A machine as claimed in claim **3** in which the carriage displacement means includes a fluid drive and in which the piercing hammer is adapted to be operated by a pressure fluid and in which the flow of pressure fluid to the carriage driving means and the piercing hammer is in parallel from the same pressure fluid source.

8. A machine as claimed in claim **3** which includes a jack for raising and lowering the hammer between raised and lowered positions.

9. A machine as claimed in claim **3** which includes measuring means adapted to displace a predetermined amount of feed material into the hopper.

10. A machine as claimed in claim **3** in which the hopper is mounted on the carriage rearwardly of the piercing hammer in the direction of displacement of the machine during the piercing operation.

11. A machine as claimed in claim **3** in which the piercing hammer is adapted to be pivoted at its upper end portion from the carriage for rocking movement in the direction toward and away from the bath.

12. A machine as claimed in claim **11** which includes means adapted to rock the piercing hammer along an arc crosswise of the cell for piercing the crust at different crosswise positions and at different angles of inclination.

13. A machine as claimed in claim **11** in which the piercing hammer is adapted to be positioned to pierce the crust at points aligned at two different crosswise positions to provide two different angles of inclination in the piercing action.

14. A machine as claimed in claim **3** in which the piercing hammer is adapted to pierce the crust initially and at the head of the first anode and at the end of the last anode in each bath and the multiple points in between disposed along a straight line perpendicular to the axis of displacement of the carriage.

15. A machine as claimed in claim **3** in which the means adapted to feed alumina from the hopper comprises a valve having a deformable diaphragm, a dosing receptacle having a rocking base and a jack for actuating the base, the deformable diaphragm valve and jack being operated by a common hydraulic feed so that the valve is closed when the bottom is open and vice versa.

16. A machine as claimed in claim 3 which includes a control for the piercing hammer for piercing operation comprises a piercing register including a series connection of logical memories, each of which is connected to trigger off the following memory and block the preceding memory, the first memory being adapted to be triggered off by an impulse N for the beginning of piercing at the head responsive from the positioning of the carriage in front of the location to be pierced, and to supply a signal R1 to electric valves controlling the positioning and piercing hammer, the signal R1 adapted to result in the transference of the piercing hammer to above the first point to be pierced and to effect the piercing operation, and wherein the even memories responsive to a signal upon displacement of the piercing hammer to lowered position being adapted to supply a signal R2, R4, etc. cause the hammer to be raised, and the odd memories other than the first, responsive to a signal resulting from displacement of the piercing hammer to raised position being adapted to supply the signals R3, R5, etc. cause the piercing hammer to be transferred and the corresponding point to be pierced.

17. A machine as claimed in claim 3 in which the machine is adapted for continuous piercing of one anode after another in each bath and one bath after another in the series, comprises a register of returns which controls the return to the starting position in response to the piercing of a predetermined number of baths for purposes of refilling the machine with alumina followed by the uninterrupted passage of the machine in front of the pierced bath, the register of returns comprising a series connection of memories each of which is adapted to energize the next memory and block the preceding memory for each return to starting position, a group of three memories of which the first and third are adapted to the energized by a signal F emanating from a counter of the number of baths already pierced, the second being adapted to be energized by the beginning of a series signal delayed by the time RC6 required for refilling the machine, each of said memories supplying a signal U respectively resulting in return of the head of the series in the case of the first memory and uninterrupted passage in front of the baths already pierced in the case of the second memory and piercing the predetermined number of baths which follow in the case of the third memory.

18. A machine as claimed in claim 3 in which the machine is adapted for continuous piercing, said machine being adapted to pierce a single anode in each bath during each run and wherein the piercing order is given by a signal Γ translating the coincidence between a digit D, indicating the number of runs, and a digit F, indicating for each bath the number of anodes the carriage has passed.

19. A machine as claimed in claim 3 which includes a special energizing winding on each bath, a corresponding proximity detector on the carriage and a memory actuated by the detector and wherein the signal from the memory is adapted to be stored during the process of piercing the corresponding bath to prohibit feeding with alumina.

20. A machine as claimed in claim 19 in which the special winding is adapted to be energized by a signal from a pilot anode in which the current density is chosen so that the polarization of the anode corresponds to a dissolved alumina content of between 4 and 7 percent, and wherein the winding is adapted to be de-energized by a signal from the same pilot anode in which the current density is selected so that its polarization corresponds to a dissolved alumina content of between 1.5 and 4 percent.

21. A machine as claimed in claim 3 which is adapted to respond to burning summons and comprises a relay on the bath which is adapted to send the burning summons to a lead common to the series of baths, a winding energized by the relay, a proximity detector on the carriage adapted to be energized by the winding whereby the carriage, started by the burning summons, is adapted to be displaced to the bath in question and proceeds to effect the described piercing and feeding operation, the corresponding register being engaged by the proximity detector.

22. A machine as claimed in claim 3 which responds to pre-burning summons and which comprises a relay on the bath connected to send the pre-burning summons into a lead common to the series of baths, a winding energized by the relay, and a proximity detector on the carriage adapted to be energized by the winding whereby the carriage in response to pre-burning summons is adapted to be energized in front of the bath and to effect the described piercing and feeding operations, the corresponding register being engaged by the proximity detector.

23. A machine as claimed in claim 3 which responds to burning and pre-burning summons and wherein the pre-burning circuit comprises a prohibiting input adapted to be acted upon by the burning signal to give priority to the latter.

24. A machine as claimed in claim 23 wherein each of the baths to be served comprises a burning relay adapted to be energized in response to the potential difference between the anode system and the cathode and a pre-burning relay adapted to be energized in response to the potential difference between an auxiliary anode (pilot anode) which is maintained at a higher current density than that of the anode circuit of the bath, each burning relay comprising a contact adapted to send a burning signal when the relay is energized into a lead common to all of the burning relays and in which each pre-burning relay comprises a contact adapted to send a pre-burning signal when the relay is energized into a lead common to all pre-burning relays, each burning and pre-burning relay also having a contact which is adapted to actuate a winding E fixed to the bath and which, upon acting on a proximity detector DPE, is adapted to stop the carriage opposite the bath in question and cause it to carry out its piercing and feeding operations, each burning relay having a contact which, when said relay is adapted to be energized, cuts off the supply to the winding E of all of the baths across the pre-burning relays.

25. An installation, as claimed in claim 3, which includes two machines aligned on each side of a series of aligned baths, one machine being adapted to carry out the described piercing and feeding operations while the other remains in reserve for response to at least one of the summons including a burning summons and a pre-burning summons wherein the first machine is adapted to be connected with a transmission circuit which is adapted to respond only to signals of phase ϕ and a circuit which emits a signal of phase θ when the machine is started, the second machine being adapted to be connected to a transmission circuit responsive only to signals of phase θ and a circuit which emits a signal of phase ϕ when the machine is started, the signal emitted by each machine being adapted to provide a prohibition to the transmission circuit of the other machine so that the machine which is started first begins the piercing and feeding operation and prohibits the other machine from effecting the same operations whereby the other machine remains in reserve for response to summons.

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