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AFATL-TR-71-107

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**7.62MM NONROTATING, EXTERNALLY
POWERED, MULTIPLE-BARREL GUN**

**GENERAL AMERICAN RESEARCH DIVISION
GENERAL AMERICAN TRANSPORTATION CORPORATION**

TECHNICAL REPORT AFATL-TR-71-107

AUGUST 1971

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7.62MM Nonrotating, Externally Powered, Multiple-Barrel Gun

Paul E. Stewart
Philip A. Saigh

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FOREWORD

This report was prepared by General American Research Division (GARD) of General American Transportation Corporation, 7449 North Natchez Avenue, Niles, Illinois 60648 in fulfillment of the work required under Contract No. F08635-69-C-0157 for the design, development, and fabrication of a firing model of a 7.62mm nonrotating, externally powered, multiple-barrel gun. The program, designated as GARD Project 1485, was performed under the technical supervision of the Air Force Armament Laboratory (DLDG), Eglin Air Force Base, Florida. Work on this program was initiated on 13 April 1970 and concluded on 13 July 1971. The program monitor for the Armament Laboratory was Mr. Earl Wilson.

The assistance and guidance of Air Force Armament Laboratory personnel, particularly Messrs. Dale M. Davis and Earl Wilson, is acknowledged.

This technical report has been reviewed and is approved.


LEMUEL D. HORTON, Colonel, USAF
Chief, Guns and Rockets Division

ABSTRACT

The development of a 7.62mm gun is described together with drawings, photographs, a firing summary, and a series of diagrams to illustrate the flow of rounds. The gun features a stationary barrel cluster. Rotating around the barrel cluster is a planetary mechanism that feeds and removes ammunition from the gun. The planetary mechanism is supplied by a continuous flow delinker/feeder that accepts linked ammunition. The gun was designed to use standard 7.62mm mini-gun barrels, bolt assemblies, bolt guides, and a gun rotor which is altered for this application. A 24-volt DC electric motor is used to drive the weapon system.

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SECTION 1

INTRODUCTION

At the present time the 7.62mm GAU-2/A and the 20mm M61 guns constitute the prime high rate of fire guns used by the Air Force. Both of these six-barrel weapons operate on the Gatling principle wherein the barrel cluster rotates. This rotation imparts a tangential velocity to the projectile upon muzzle exit, the velocity being proportional to the rate of rotation of the barrel cluster. For a variable rate of fire gun, i.e., changeable barrel cluster rotational velocities, the corresponding varying tangential velocities result in different impact coordinates for each rate. As a result, tactical fighter pilots have complained of the inherent error induced in predicting target impact coordinates at varying rates of fire.

The nonrotating multiple-barrel gun principle is intended to overcome the above deficiencies of the Gatling-type guns by using a mechanism which circulates around the stationary barrels to feed, load, fire, and clear each barrel in turn, while the mechanism itself is replenished from an ammunition magazine. This operating principle offers a definite advantage over the Gatling principle in that the external drive system is not required to accelerate the relatively massive inertia associated with the six rotating barrels. The anticipated lower inertia associated with the rotating squirrel cage feeder used with the nonrotating barrel system will result in a more rapid acceleration to full rate of fire. Furthermore, the stationary-barrel gun should result in a better hit probability at all rates of fire when compared to a Gatling-type gun where there are constantly varying barrel rotational velocities during the acceleration and deceleration phases as well as different velocities associated with each rate and correspondingly fewer rounds out of a given burst placed on the target.

This effort for a 7.62mm firing gun is a follow-on to a previous effort during which a hand-operated non-firing model was designed and fabricated. The results of this earlier effort are contained in Technical Report AFATL-TR-70-12, Nonrotating, Externally Powered Multiple-Barrel Gun, dated January 1970.

Several major changes were incorporated into the design of the firing gun. The conveyor has been replaced with a delinker/feeder that accepts belted 7.62mm ammunition, a 24-volt electric drive motor has been added, and the gun has been redesigned to use as many 7.62mm GAU-2/A components as possible, including barrels, bolt assemblies, bolt guideways, and a gun rotor which is altered for this application. It has fired bursts of 200 rounds in length; a peak firing rate of 5400 shots per minute (SPM) has been recorded during the test phase of this program.

SECTION 11

WEAPON SYSTEM DESIGN

2.1 Basic Design Concept

The gun with the drive motor assembly and the delinker/feeder mounted to it is shown in Figure 1 and schematically illustrated in Figure 2. It consists of six barrels equally spaced on a 2-1/2-inch circle, a barrel support, six bolt assemblies, a recoil adapter assembly, and a barrel clamp; all of these are nonrotating components. The major rotating components include the main drive cam assembly, the rear cover assembly, the transfer sprocket, and the squirrel cage assembly which includes the 160-tooth gear. The drive cam rotates around the barrel support one revolution for every six rounds fired, or 60° per round. The cam drives the bolt assemblies forward and rearward during operation and locates the bolt head so it can accept an incoming round and retain the round during ramming and extraction by engaging the extraction groove. Attached to the drive cam assembly is a 144-tooth gear.

A squirrel cage is located on the outside diameter of the drive cam. Assembled to the cage are 24 screws equally spaced on a 6.00-inch pitch diameter. The screw heads are undercut so they engage the extraction grooves of the rounds. This is the method used to control the flow of ammunition through the gun system.

A six-tooth 1-1/2-inch pitch diameter transfer sprocket rotates around the barrel support with the drive cam. Its purpose is to engage live ammunition in the squirrel cage and place it into the appropriate bolt head. The transfer sprocket is fitted with three sets of holding pawls that are cam-controlled to achieve this transfer from squirrel cage to gun. After firing, the spent brass is re-engaged by the transfer sprocket in the spaces between the teeth containing the holding pawls and replaced in the squirrel cage.

The flow of ammunition through the weapon can be traced if the motion relationships are borne in mind. The squirrel cage rotates 20° clockwise per gun cycle while the transfer sprocket and the drive cam moves 60° in the same direction per gun cycle. The transfer sprocket also rotates on its own axis 120° counterclockwise per gun cycle. The system is similar to a planetary gear train where the barrel cluster is the "sun" gear, the transfer sprocket is the "planet" pinion, and the squirrel cage is the internal gear. The mechanics of operation of the weapon system is illustrated in Appendix I. Figures I-1 through I-42 show the continuous flow of ammunition during the first 42 gun cycles from the time the first round is introduced from the delinker/feeder into the squirrel cage until expended brass is ejected from the squirrel cage. Figures II-1 through II-17 illustrate the major sub-assemblies and details of the weapon system.

2.2 Description of Gun

The complete weapon system is 8-1/2 inches wide, 8-1/2 inches high, and 32-3/4 inches long when fitted with 22-inch barrels. The total weight is

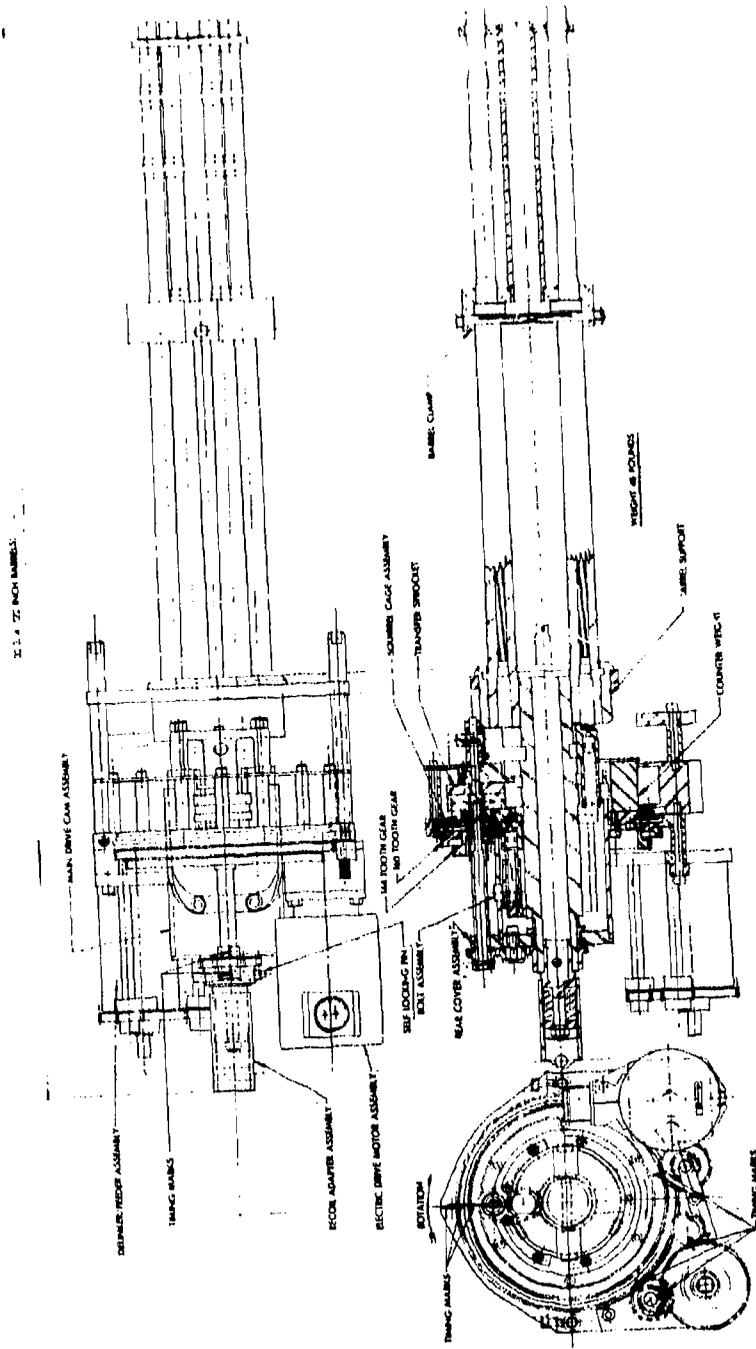


Figure 1. 7.62mm Nonrotating, Externally Powered Gun

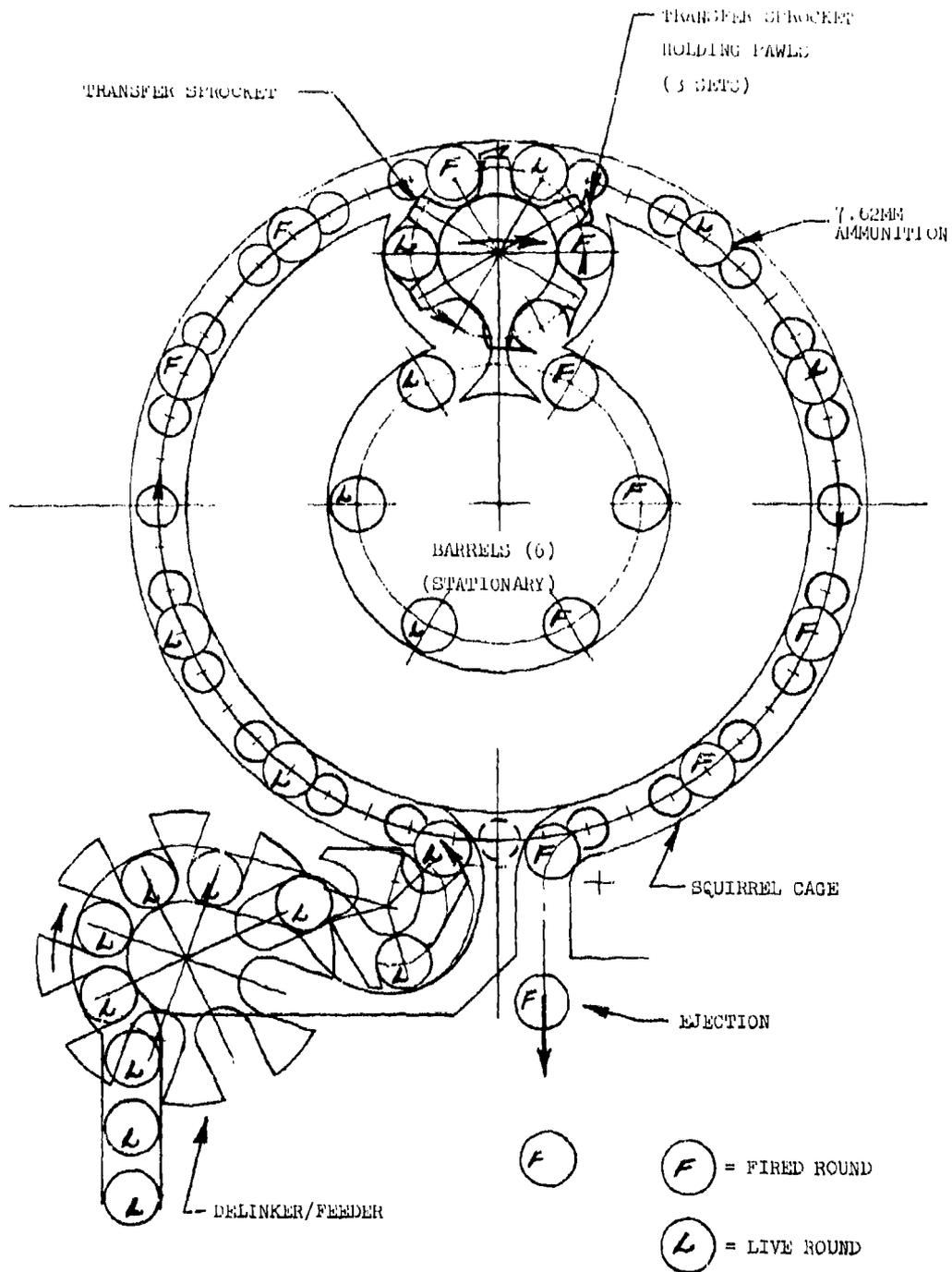


Figure 2. Nonrotating Gun Concept

48 pounds. A breakdown of this weight follows:

<u>Nonrotating Parts</u>	<u>Weight (lb)</u>	<u>Rotating Parts</u>	<u>Weight (lb)</u>
Barrels (6)	14	Squirrel Cage (with 160T gear)	3
Bolt Assemblies (6)	1-1/2	Drive Cam (with 144T gear)	4
Barrel Support	9-1/2	Rear Cover Assembly	1
Delinker/Feeder	8	Counterweight	1-1/2
Drive Motor Assembly	4	Transfer Sprocket and Guides	1-1/2
	<u>37</u>		<u>11</u>

2.3 Gear Train

The gear train transmits torque and maintains timing during operation of the weapon system. It is shown in Figure 3 and is composed of a total of thirteen gears: two in the drive motor assembly, four in the feeder/delinker assembly, and seven in the gun.

When energized, the drive motor transmits torque through a 21-tooth pinion which is attached to the motor shaft and an idler gear which has 24 teeth. The idler gear is in mesh with a 36-tooth gear which meshes with a 144-tooth gear attached to the drive cam. A 20-tooth gear is pinned to the same shaft as the 36-tooth gear and rotates with it. It meshes with a 160-tooth gear which is part of the squirrel cage assembly; thus, when the squirrel cage rotates one revolution, the drive cam rotates twice and in the same direction.

A 28-tooth gear is pinned to the barrel support on the axis of the gun. It does not rotate. A 15-tooth idler gear which is part of the rear cover assembly is in mesh with it and rotates around its own axis as the rear cover assembly rotates around the barrel support. A 14-tooth gear is pinned to the transfer sprocket shaft and meshes with a 15-tooth idler. This arrangement causes the transfer sprocket to rotate two revolutions in a counterclockwise direction every time the rear cover assembly rotates once around the gun axis in a clockwise direction. This is the method used to transfer ammunition from the squirrel cage to the gun and back again.

Power to operate the delinker/feeder is transmitted by the 160-tooth gear. It meshes with a 30-tooth gear. Attached to the other end of the shaft is an 18-tooth gear that meshes with a 64-tooth gear. This 64-tooth gear is pinned to the center shaft of the delinker/feeder to which is assembled the sprockets to pull linked ammunition belts into the delinker/feeder mechanism. A 24-tooth gear is in mesh with the 64-tooth gear. A three-tooth sprocket is pinned to the other end of the shaft to which the 24-tooth gear is pinned. It accepts rounds after delinking has occurred and feeds them into the proper positions in the squirrel cage.

All the gears have timing marks, as shown in Figure 3. These must be strictly observed during assembly or the weapon system will jam.

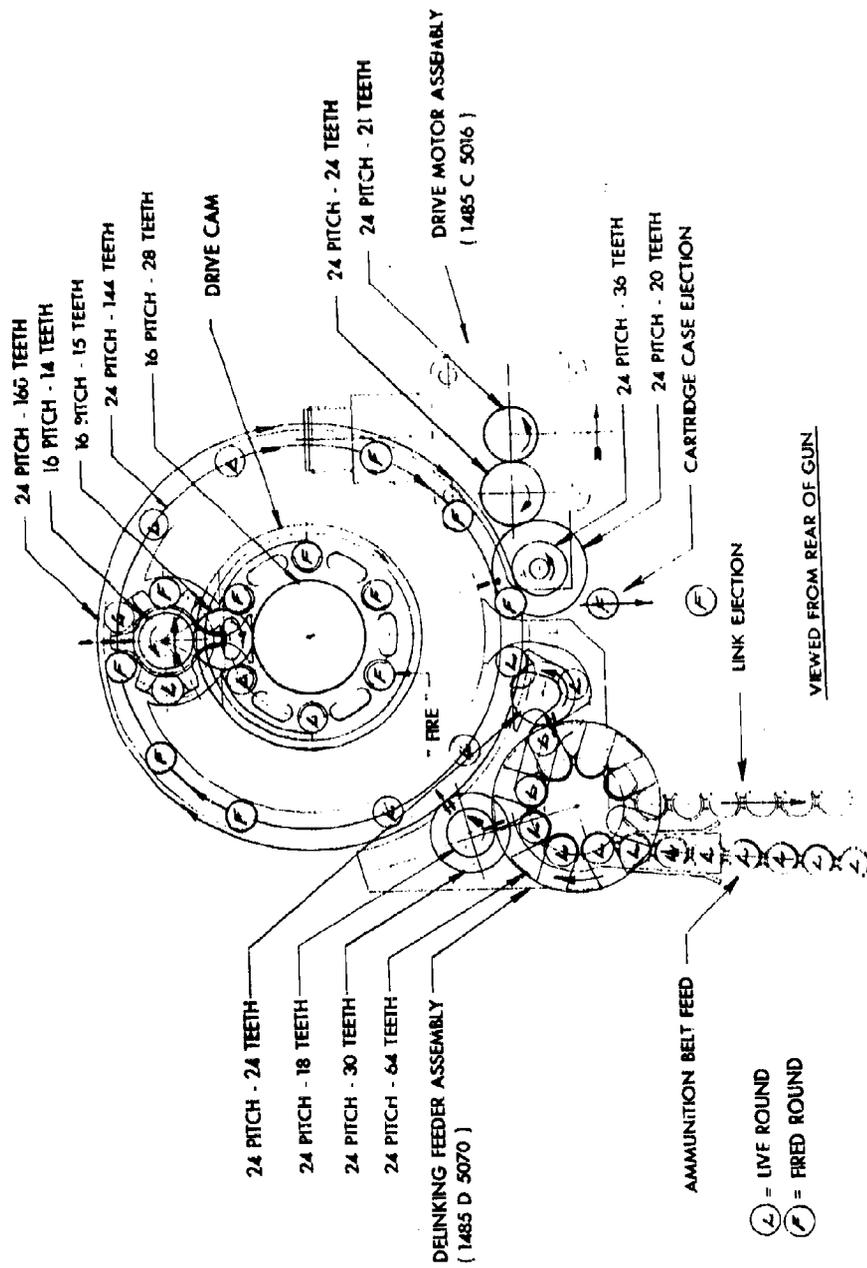


Figure 3. Gear Train

2.4 Delinker/Feeder

The delinker/feeder assembly accepts linked ammunition belts and strips rounds from links by pushing them forward out of engagement with the links. The pushers are cam-controlled and travel 1-13/16 inches in a forward and rearward direction. After stripping, the links are ejected from the delinker/feeder; meanwhile, the rounds are accelerated to a 1.00-inch pitch distance between rounds from a 0.58-inch pitch distance when in the ammunition belt. They are then engaged by a three-tooth feed sprocket which accelerates them to a 1.57-inch pitch distance. This matches the pitch distance of the squirrel cage and the transfer sprocket and results in a smooth transition since there is no change in velocity.

2.5 Drive Motor Assembly

Power to drive the weapon is obtained from a small, fractional horsepower electric motor. It is held in position on the gun by an undercut stud which accepts the assembly front plate and is locked by a single self-locking pin.

The motor is a 28-volt DC 7/16 HP, 21 amperes at 8000 RPM. Temporary overloads as high as 72 volts were applied during firing tests to increase the firing rate without adverse effects.

2.6 Recoil Adapter Assembly

A single neoprene pad, composed of several 1/4-inch-thick laminations, is used to absorb the shock and vibration during firing. The recoil adapter is mounted to the rear of the barrel support, on the axis of the gun, and is held in place by a self-locking pin. This location permits a minimum of powder couple. The recoil pad is designed to minimize transmission of recoil forces to the firing mount by dissipating a portion of the recoil energy.

SECTION III

TEST FIRING SUMMARY

The test firing program was initiated at GARD on 25 September 1970 when a total of 13 rounds were successfully fired at the contractor's indoor range. With the initial firing completed, plans were made for additional testing at the contractor's Ballistic Test Station (BTS) near Colorado Springs where instrumented facilities were available.

A total of 514 rounds were fired at the Ballistic Test Station, the longest burst attempted and completed being 24 rounds. The jams that occurred indicated a need for a redesigned squirrel cage that would afford better control of expended cartridge cases when being placed into the squirrel cage by the transfer sprocket after firing. High speed motion pictures clearly show loss of round control at this time. A new squirrel cage was designed and installed. It has lugs that engage the extraction grooves of the rounds to afford the necessary control.

During November 1970, test firing continued at GARD and at the Ballistic Test Station where several belts of 48 rounds and two belts of 96 rounds were fired. An attempt to fire a 200-round burst failed due to a jam at the entrance of the delinker/feeder. The cause of the jam was rectified and a 200-round burst was fired during January at the GARD range.

Continued test firing indicated a need for a redesign of the transfer sprocket holding pawls. The present pawls did not engage enough of the circumference of rounds being transferred from the squirrel cage to the gun. The redesigned pawls were fabricated and installed in the transfer sprocket, and 185 rounds in three bursts were fired at the indoor range to check the function of the holding pawls. The belt lengths were 35, 50, and 100 rounds.

Firing tests were resumed at the Ballistic Test Station during May 1971 when the following major bursts were fired:

2 of 200 rounds
1 of 198 rounds
2 of 100 rounds
5 of 50 rounds

The following results were observed with a voltmeter and an ammeter installed in the power supply cable:

<u>Belt Length</u> (rounds)	<u>Voltage</u>	<u>Amperage</u>	<u>Peak</u> <u>Firing Rate</u> (SPM)	<u>Average</u> <u>Firing Rate</u> (SPM)
50	48	90	4800	3530
50	60	105	5100	4200
50	72	115	5400	4950

On 8 July 1971 the gun was demonstrated to interested personnel at

Eglin AFB by firing the following bursts:

- 1 of 6 rounds
- 1 of 18 rounds
- 4 of 50 rounds

To date, 3836 rounds have been fired from the gun. The maximum recorded firing rate was 5400 shots per minute. The longest burst attempted and successfully fired was 200 rounds.

SECTION IV

CONCLUSIONS AND RECOMMENDATIONS

This effort has established the practical feasibility of the nonrotating multi-barrel gun. Bursts of 200 rounds and rates up to 5400 shots per minute were recorded. As common with guns in this stage of development, the reliability was low with several jams occurring in the feed system. The majority of jams or stoppages were due to poor round control between the squirrel cage and the transfer sprocket. The present single sprocket design was selected for its simplicity, but any future model should revert back to a three-sprocket design (as contained in the non-firing model) which affords much better round control.

This firing model, together with the previous non-firing model, clearly illustrates the soundness of design. This concept is recommended for consideration in any future high performance system. This type gun should especially be effective in large calibers where the power required to rotate a conventional heavy barrel Gatling would be excessive. The stationary barrels of this design will also result in improved accuracy.

APPENDIX I

AMMUNITION FLOW DIAGRAMS DEPICTING THE
MECHANICS OF OPERATION OF THE WEAPON SYSTEM

The method of operation of this weapon system can best be described by a series of schematic illustrations. This appendix is composed of the first forty-two gun cycles starting with the first round about to enter the squirrel cage (see Figures I-1 through I-42). It is intended to show the ammunition flow during operation. The number of gun cycles shown is a random number and has no significance. It may be noted that, although rounds are fed into the gun in a consecutive manner (i.e., 1, 2, 3, 4, 5, 6, 7, 8, etc.), they are fired in the following sequence starting with the transfer sprocket in the position shown:

6 5 4 3 2 1,	(Figures I-10 through I-15)
12 11 10 9 8 7,	(Figures I-16 through I-21)
18 17 16 15 14 13,	(Figures I-22 through I-27)
24 23 22 21 20 19, etc.	(Figures I-28 through I-33)

Ejection from the gun is in another sequence:

3 4 5 6 X X,	(Figures I-18 through I-23)
9 10 11 12 1 2,	(Figures I-24 through I-29)
15 16 17 18 7 8,	(Figures I-30 through I-35)
21 22 23 24 13 14, etc.	(Figures I-36 through I-41)

In both firing and ejection sequences a series of six repeats occurs. This is due to the gun having six barrels. It enables one to predict the location of any individual round at any time, when it will fire, and when it will be ejected.

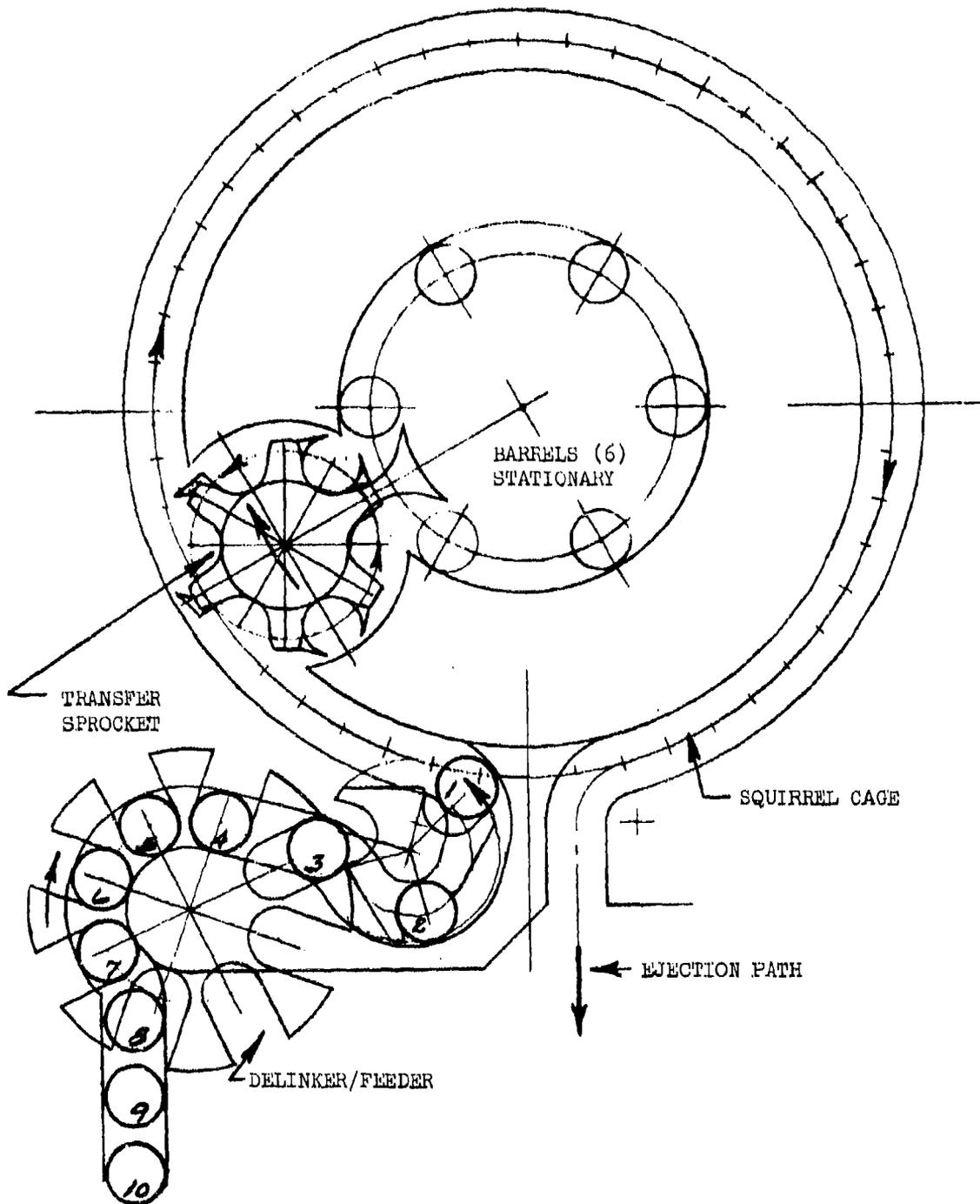


Figure I-1. Position 1: Round 1 Entering Squirrel Cage

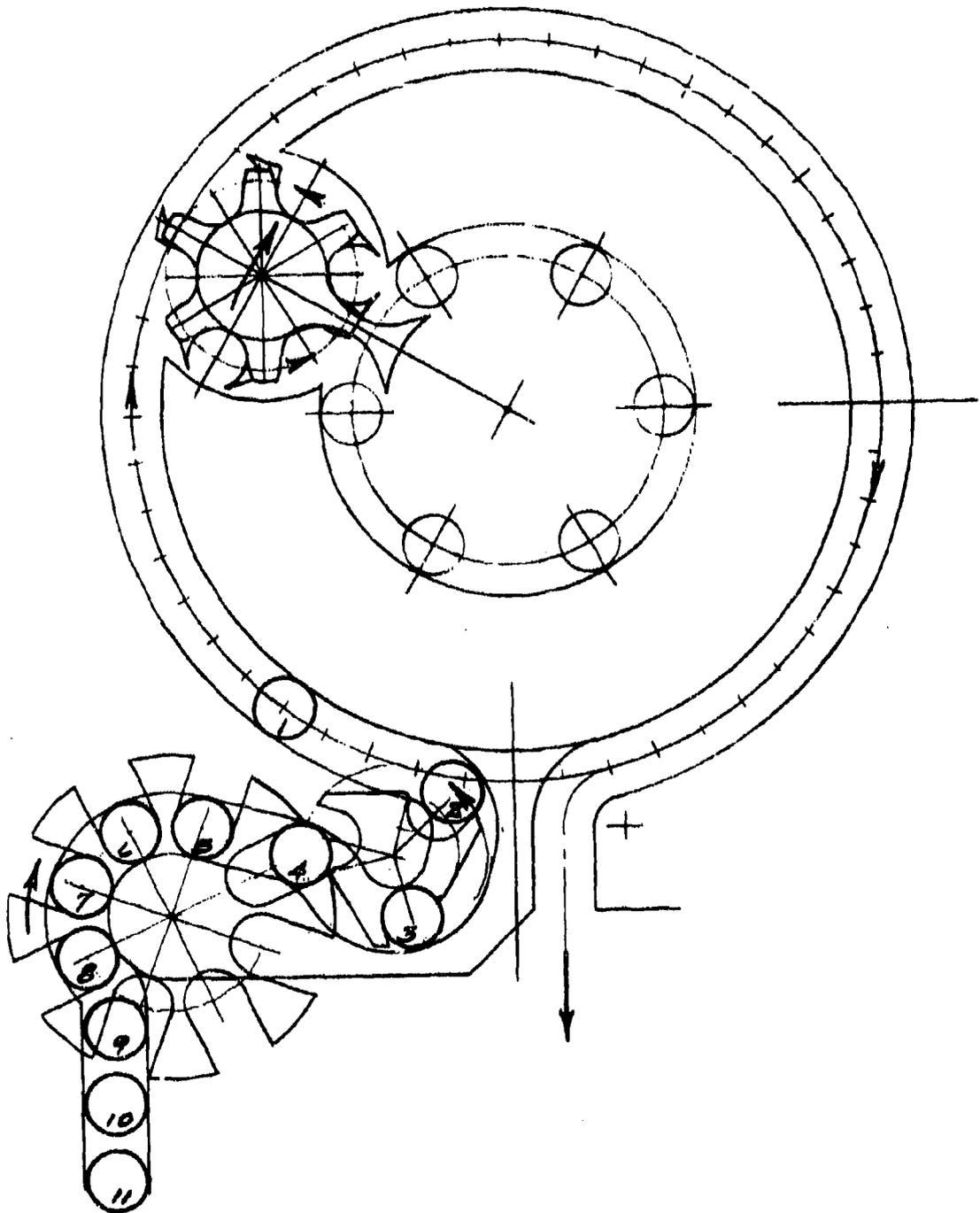


Figure I-2. Position 2: Round 2 Entering Squirrel Cage

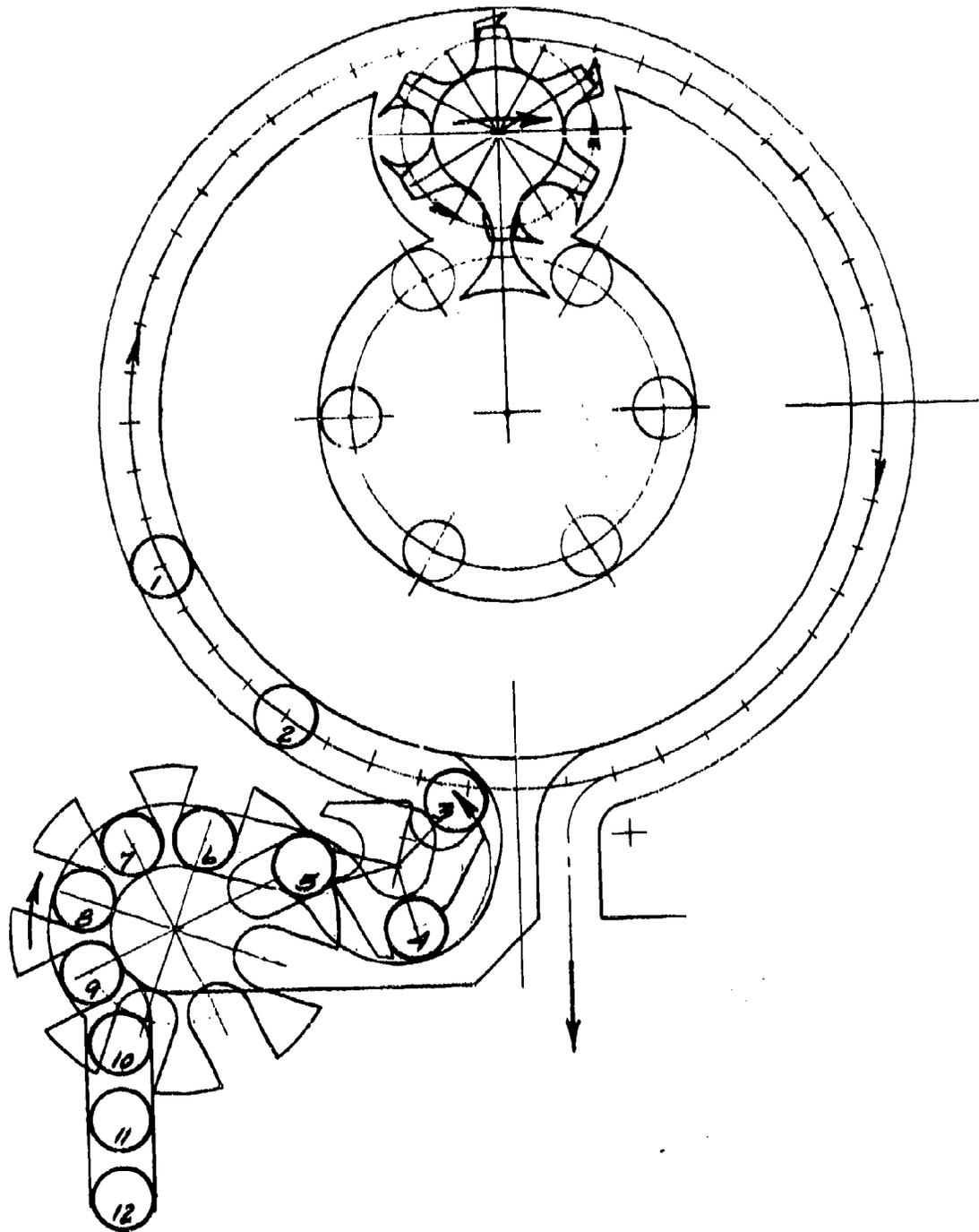


Figure I-3. Position 3: Round 3 Entering Squirrel Cage

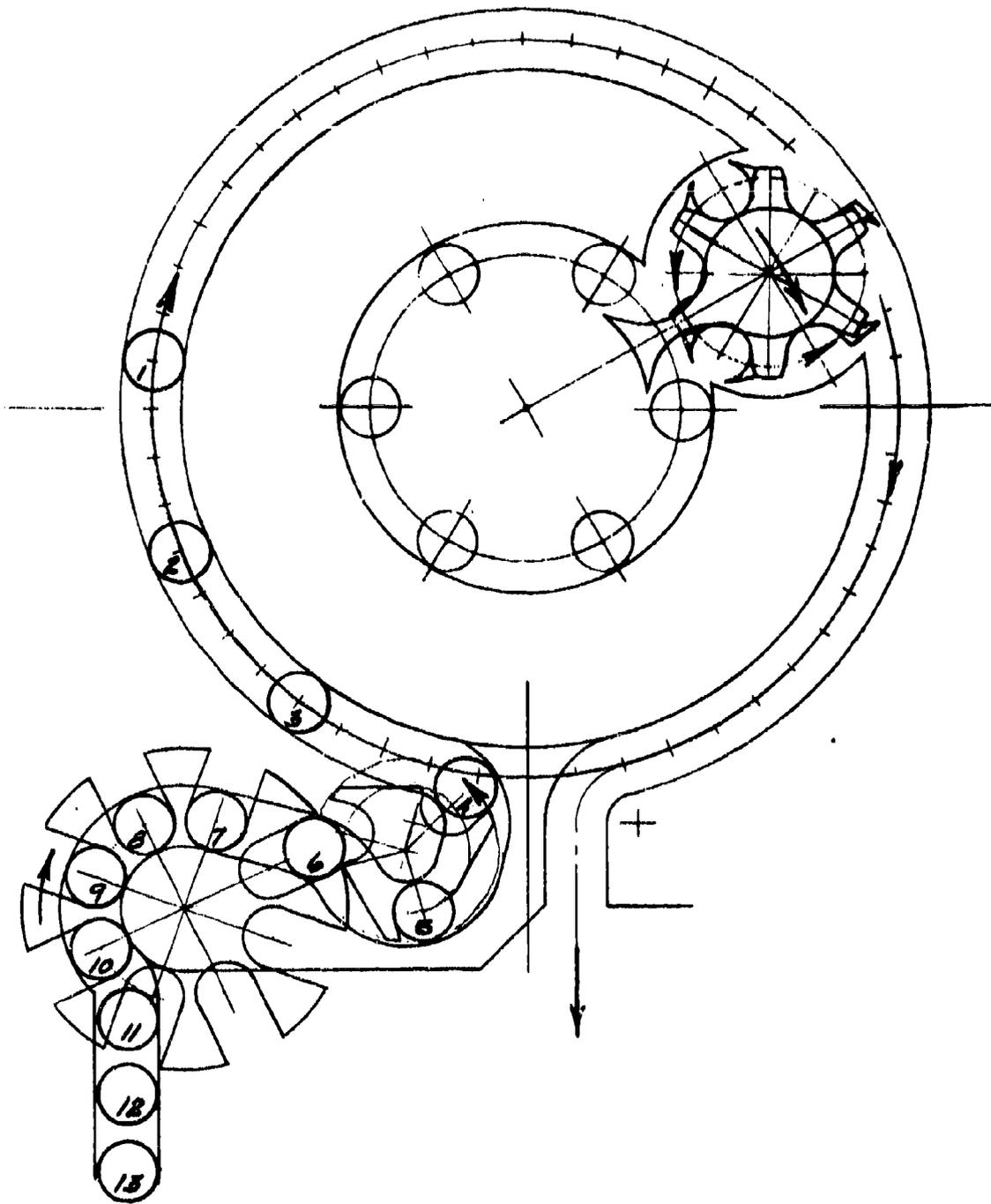


Figure I-4. Position 4: Round 4 Entering Squirrel Cage

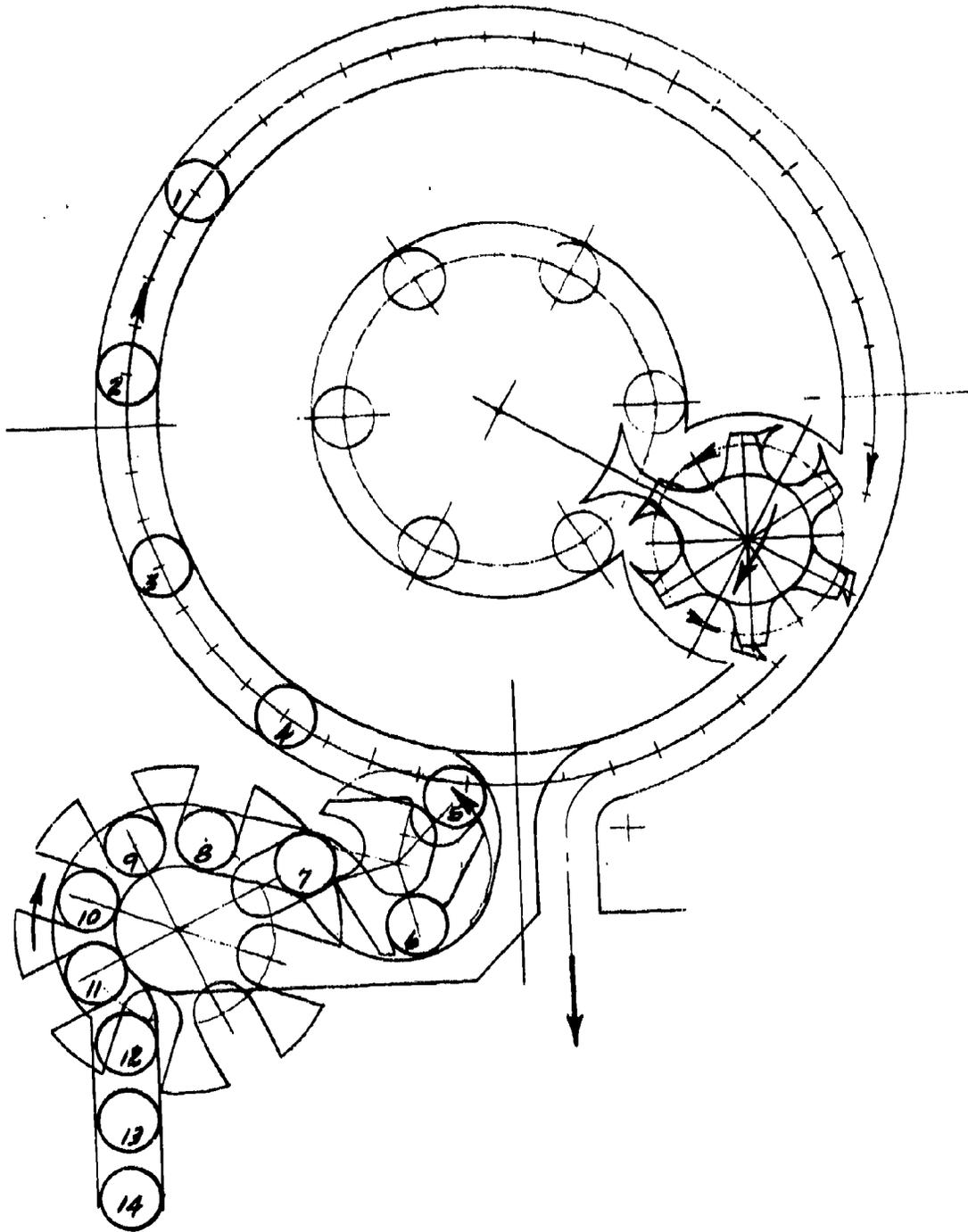


Figure I-5. Position 5: Round 5 Entering Squirrel Cage

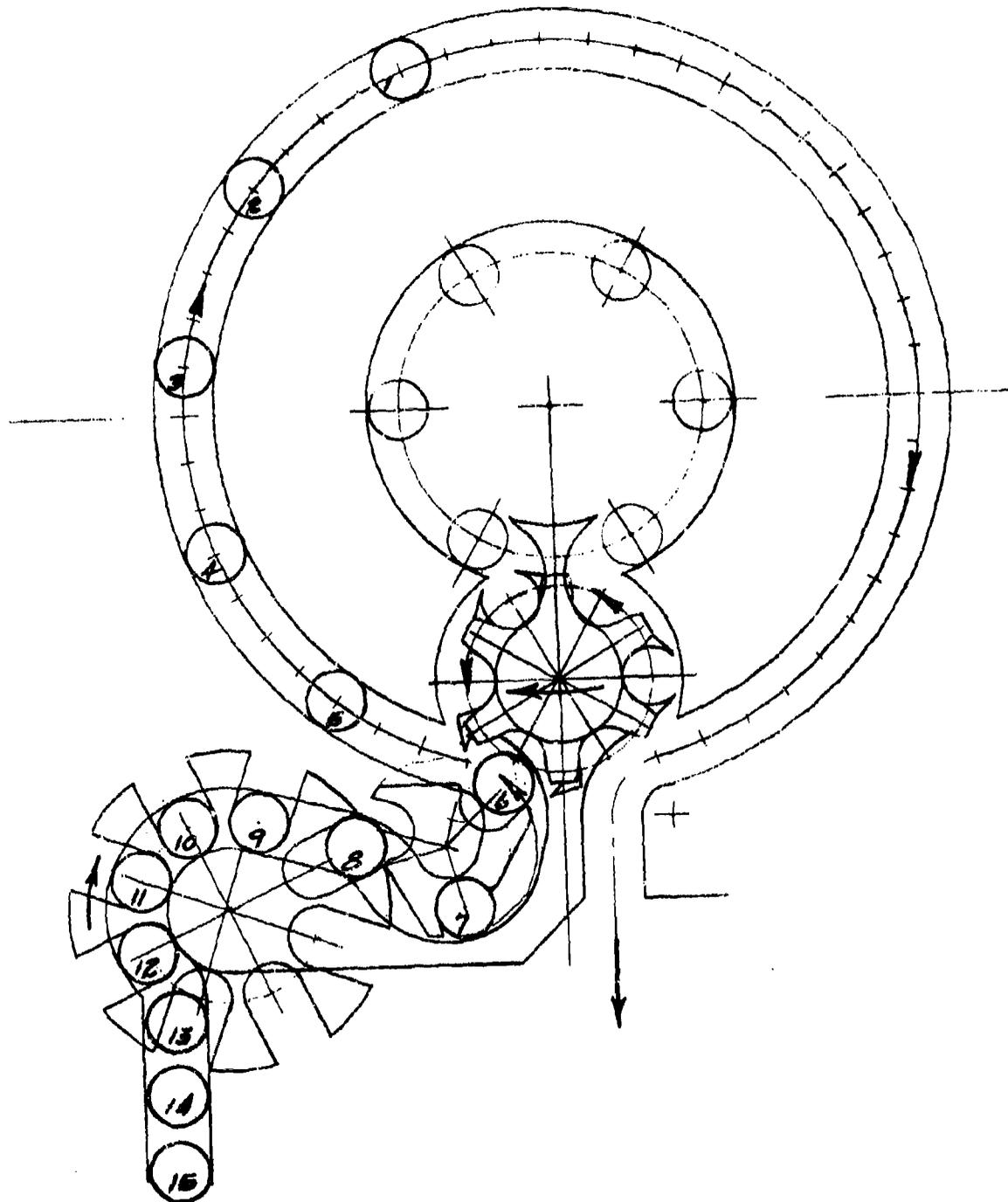


Figure I-6. Position 6: Round 6 Entering Squirrel Cage

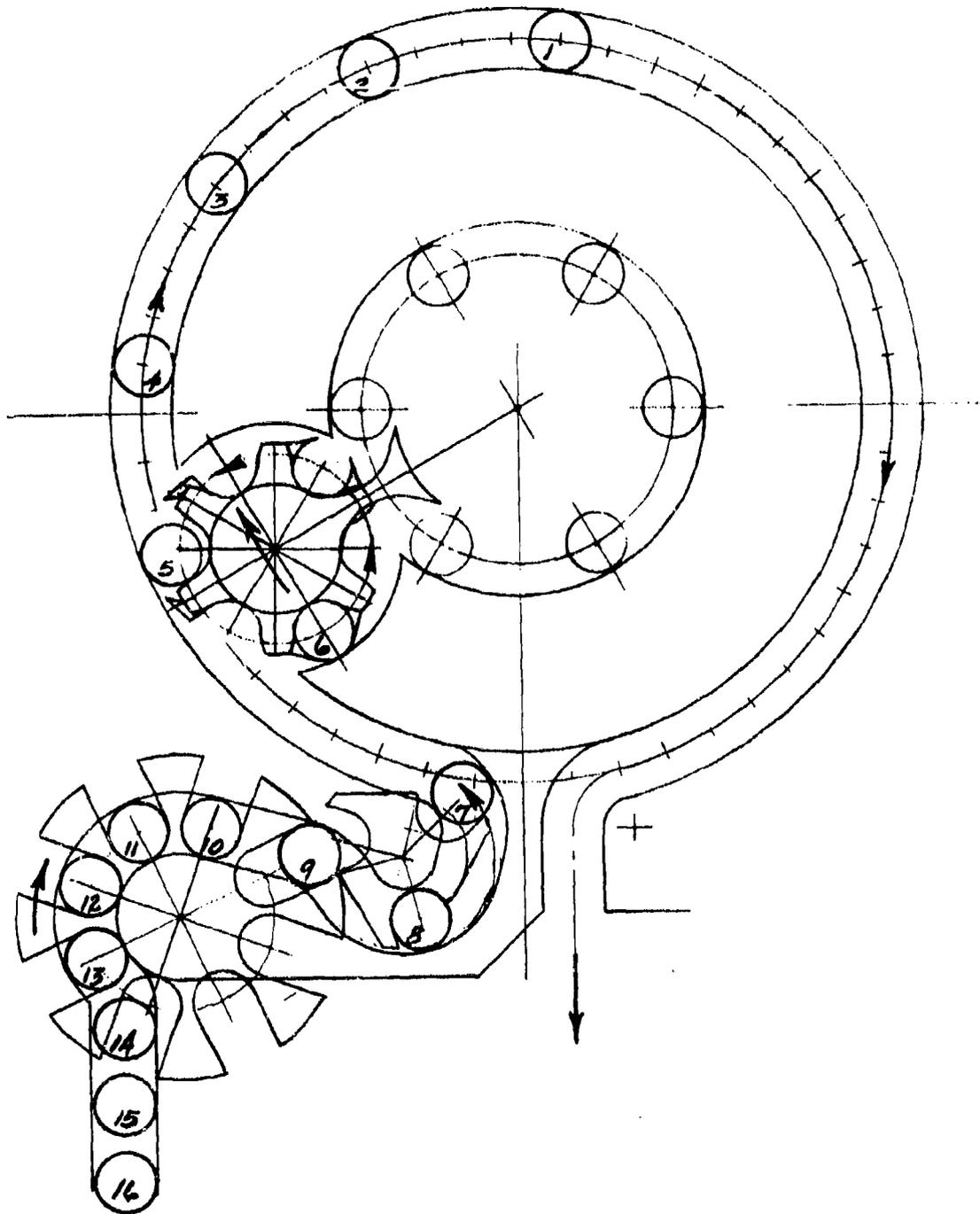


Figure I-7. Position 7: Round 7 Entering Squirrel Cage

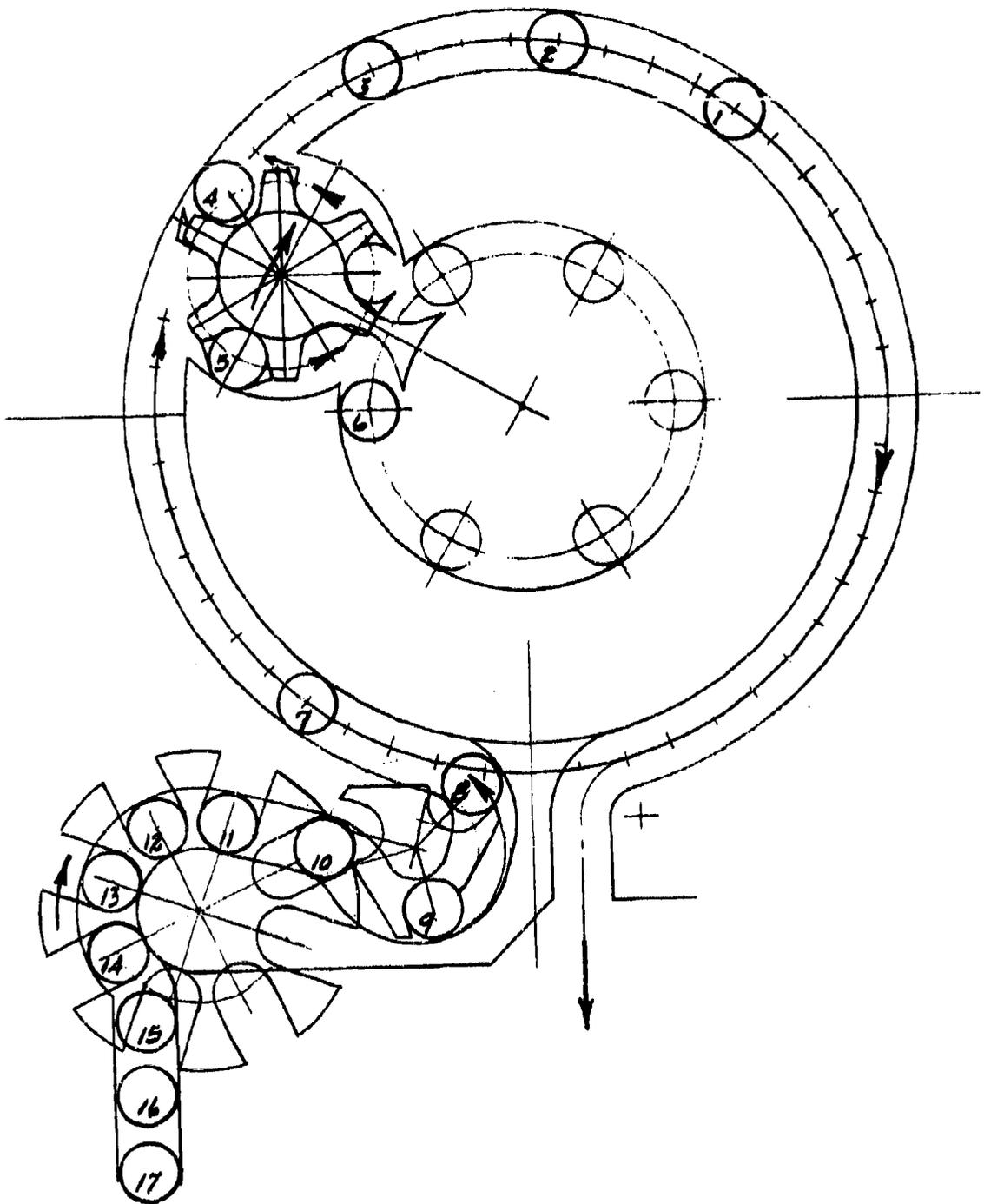


Figure I-8. Position 8: Round 8 Entering Squirrel Cage

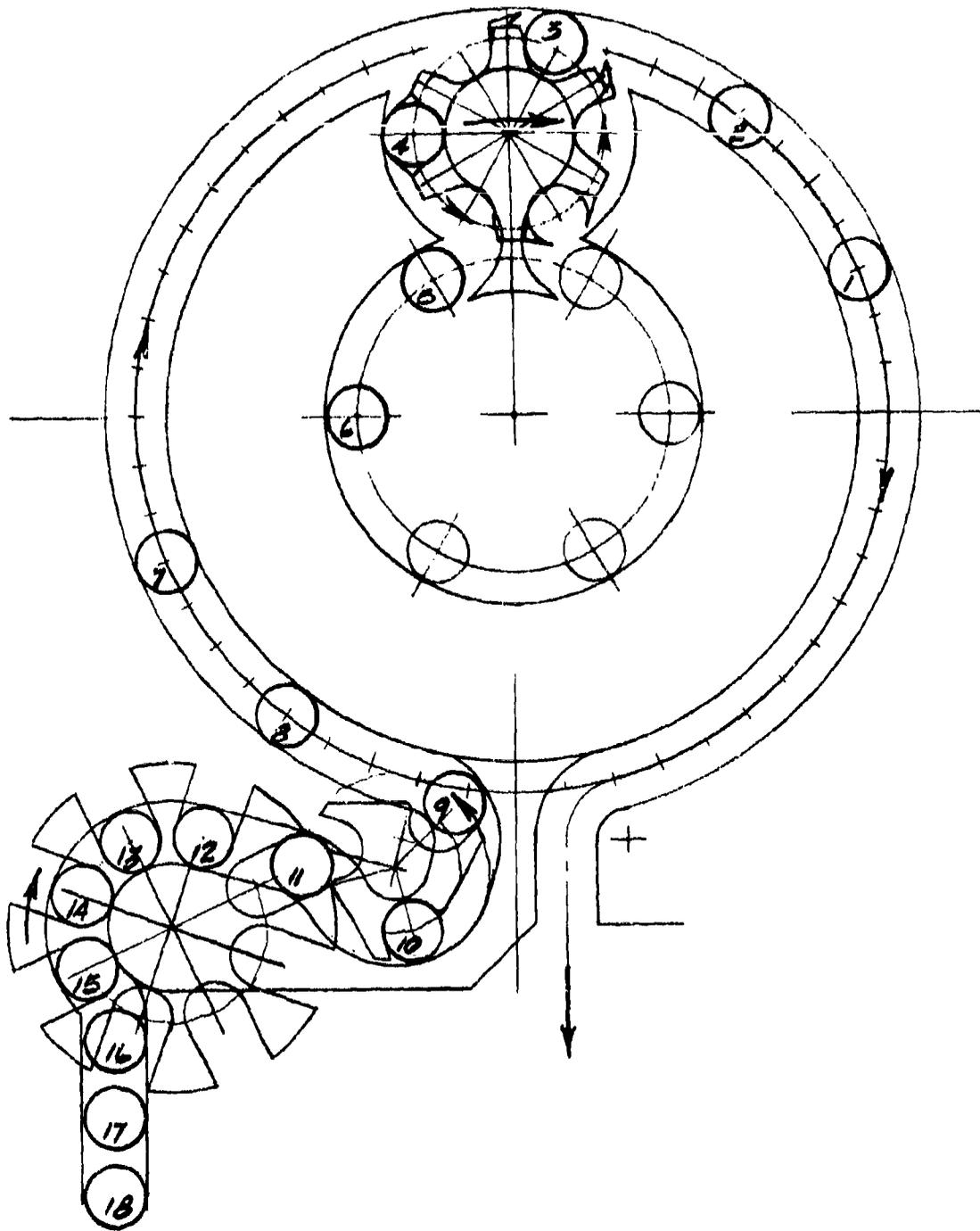


Figure I-9. Position 9: Round 9 Entering Squirrel Cage

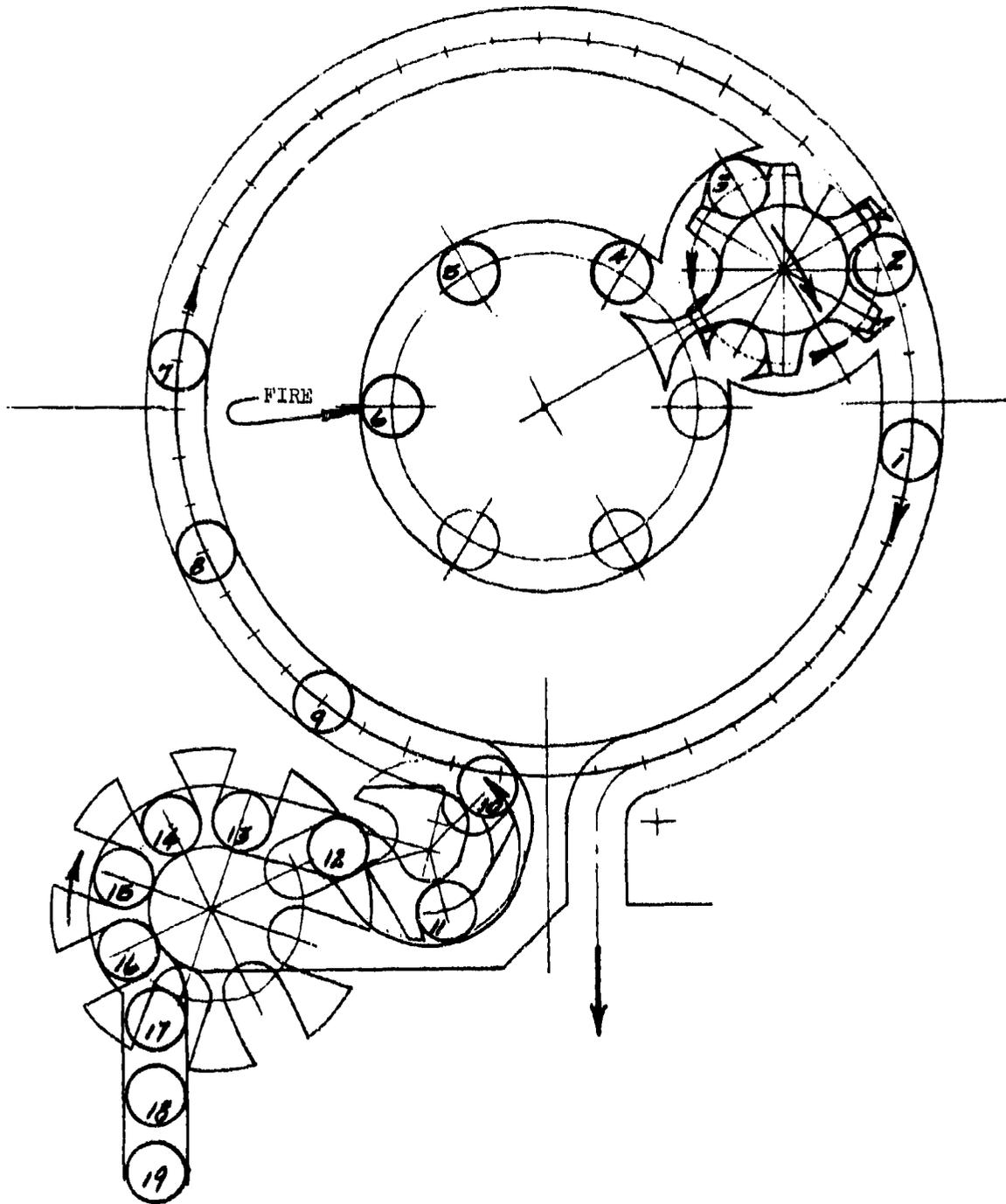


Figure I-10. Position 10: Round 10 Entering Squirrel Cage,
Round 6 Fired

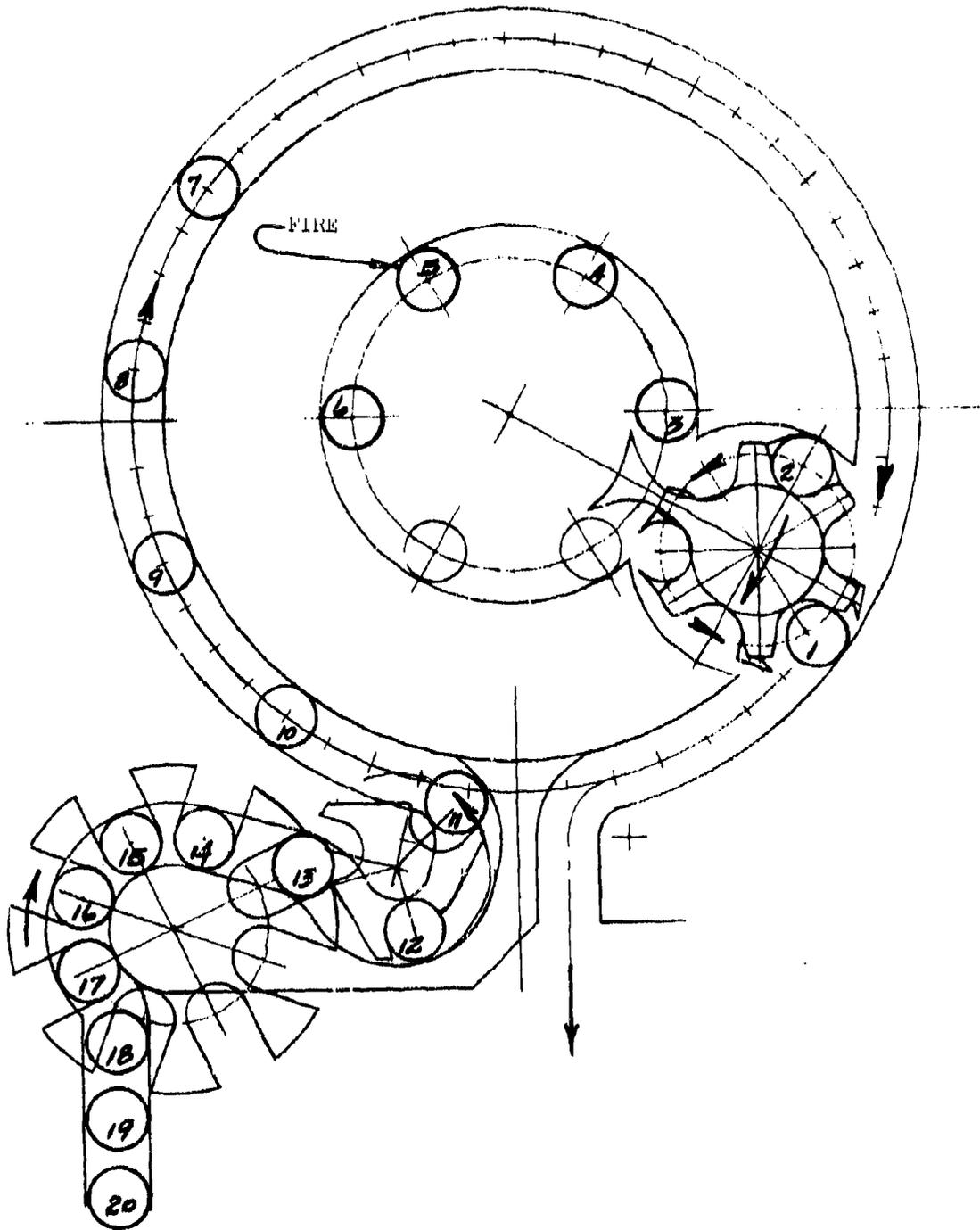


Figure I-11. Position 11: Round 11 Entering Squirrel Cage,
Round 5 Fired

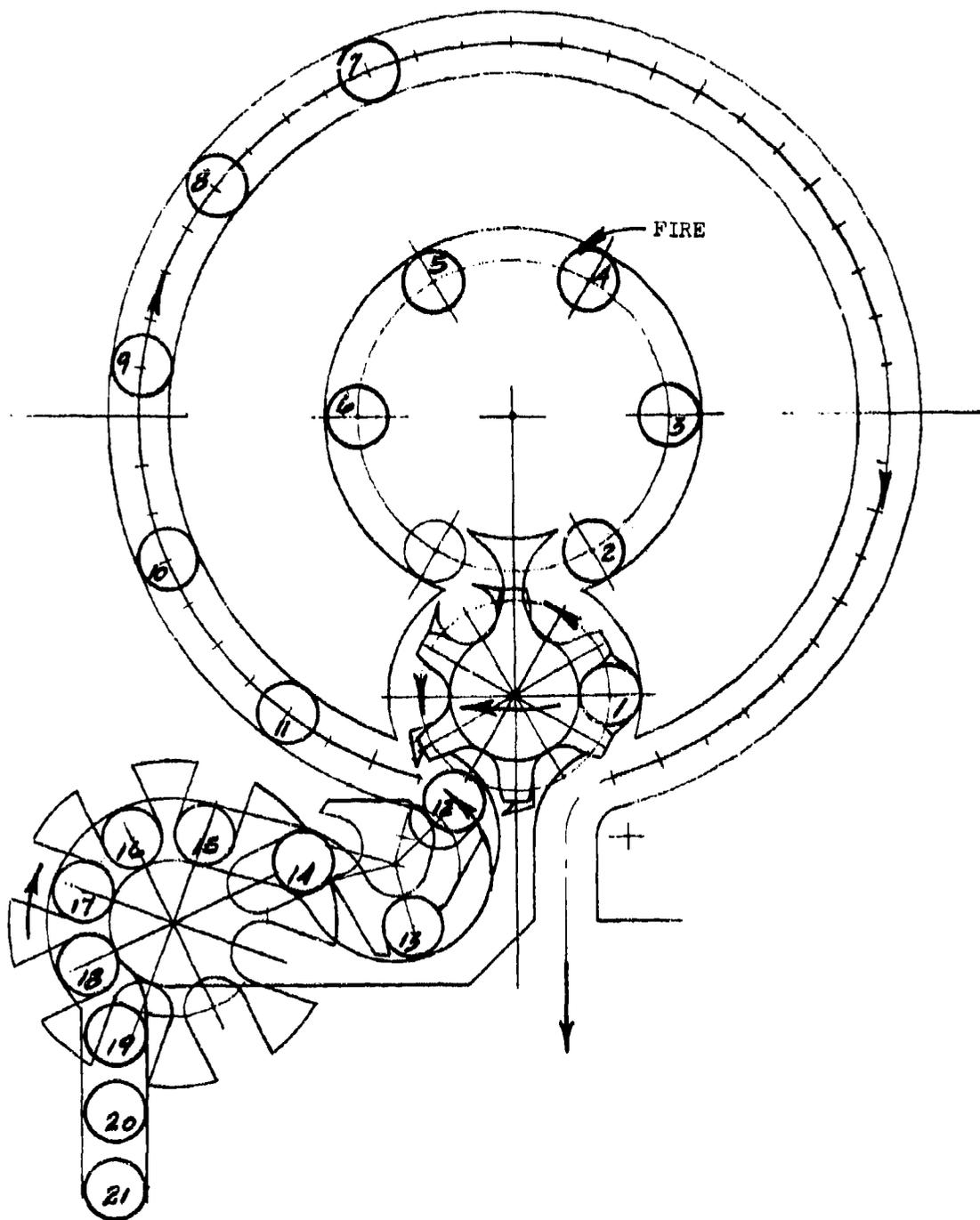


Figure I-12. Position 12: Round 12 Entering Squirrel Cage,
Round 4 Fired

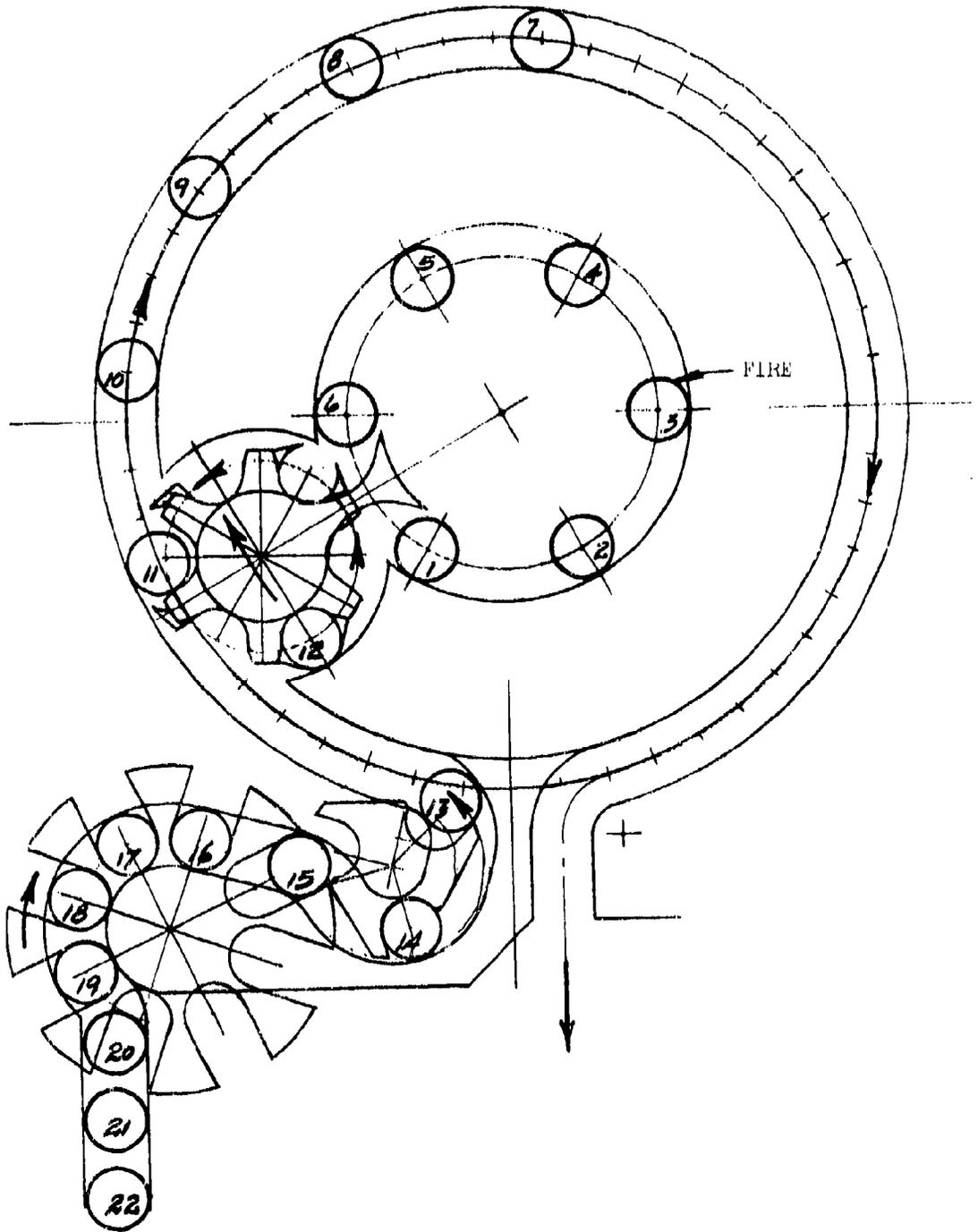


Figure I-13. Position 13: Round 13 Entering Squirrel Cage, Round 3 Fired

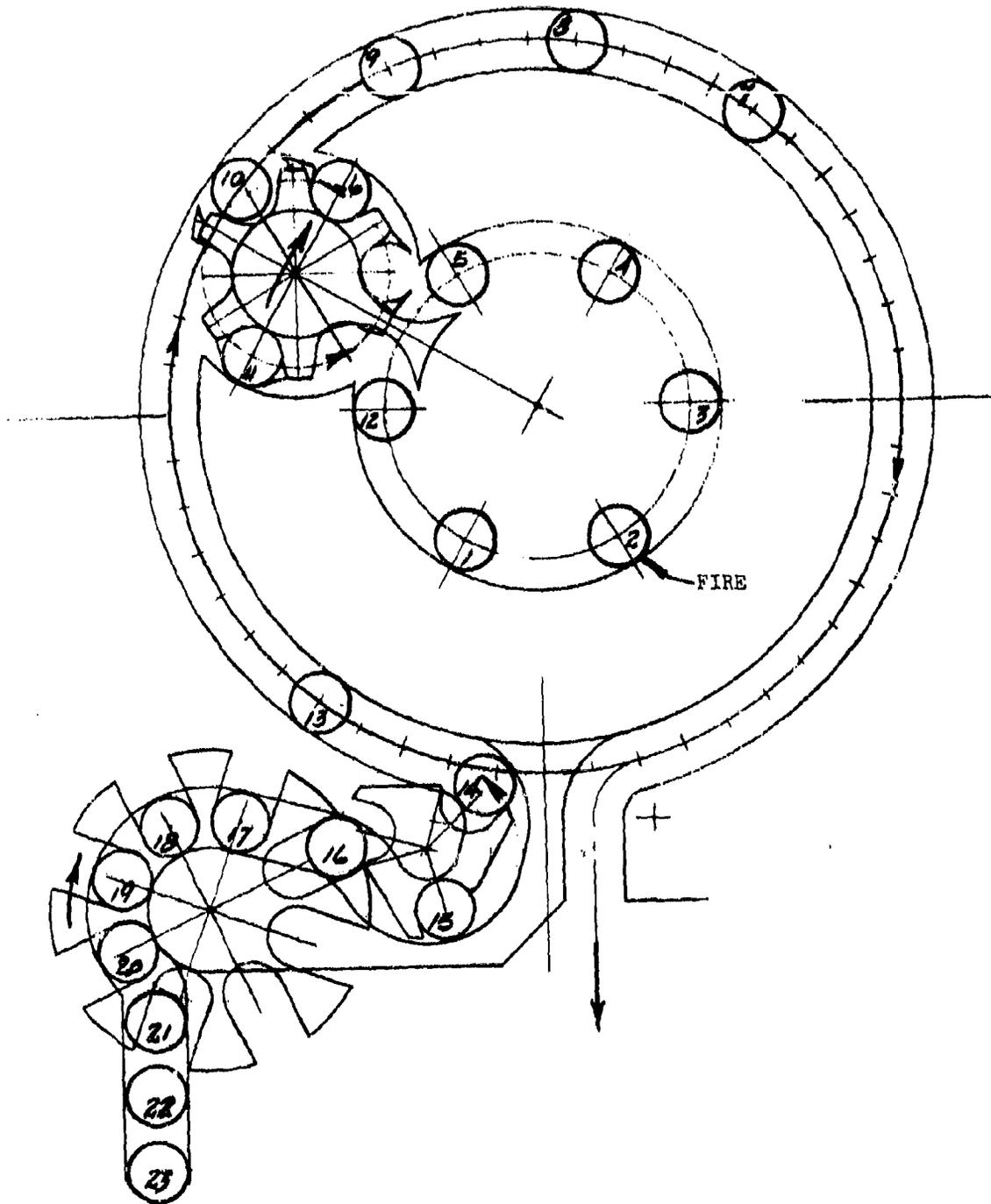


Figure I-14. Position 14: Round 14 Entering Squirrel Cage,
Round 2 Fired

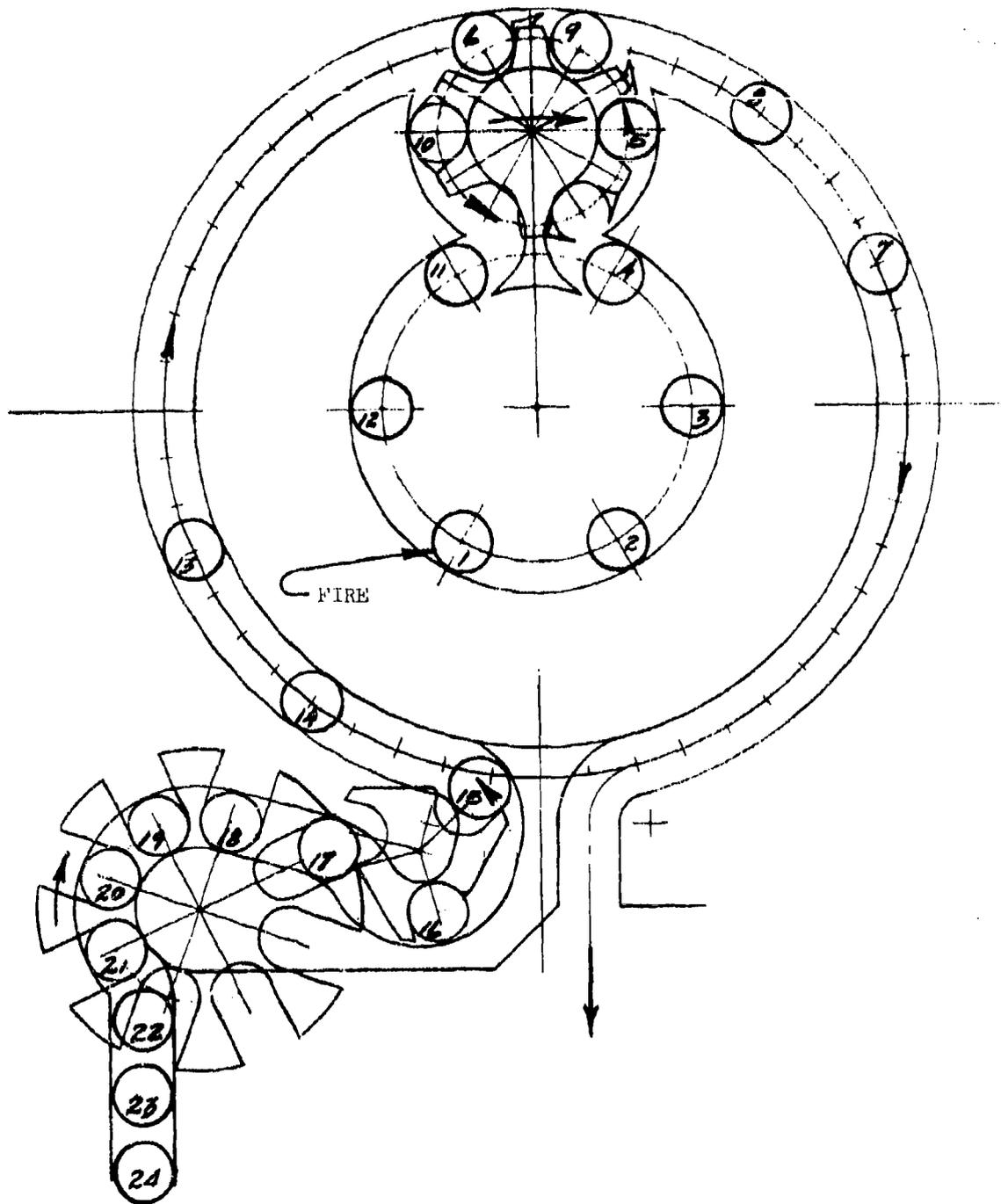


Figure I-15. Position 15: Round 15 Entering Squirrel Cage,
Round 1 Fired

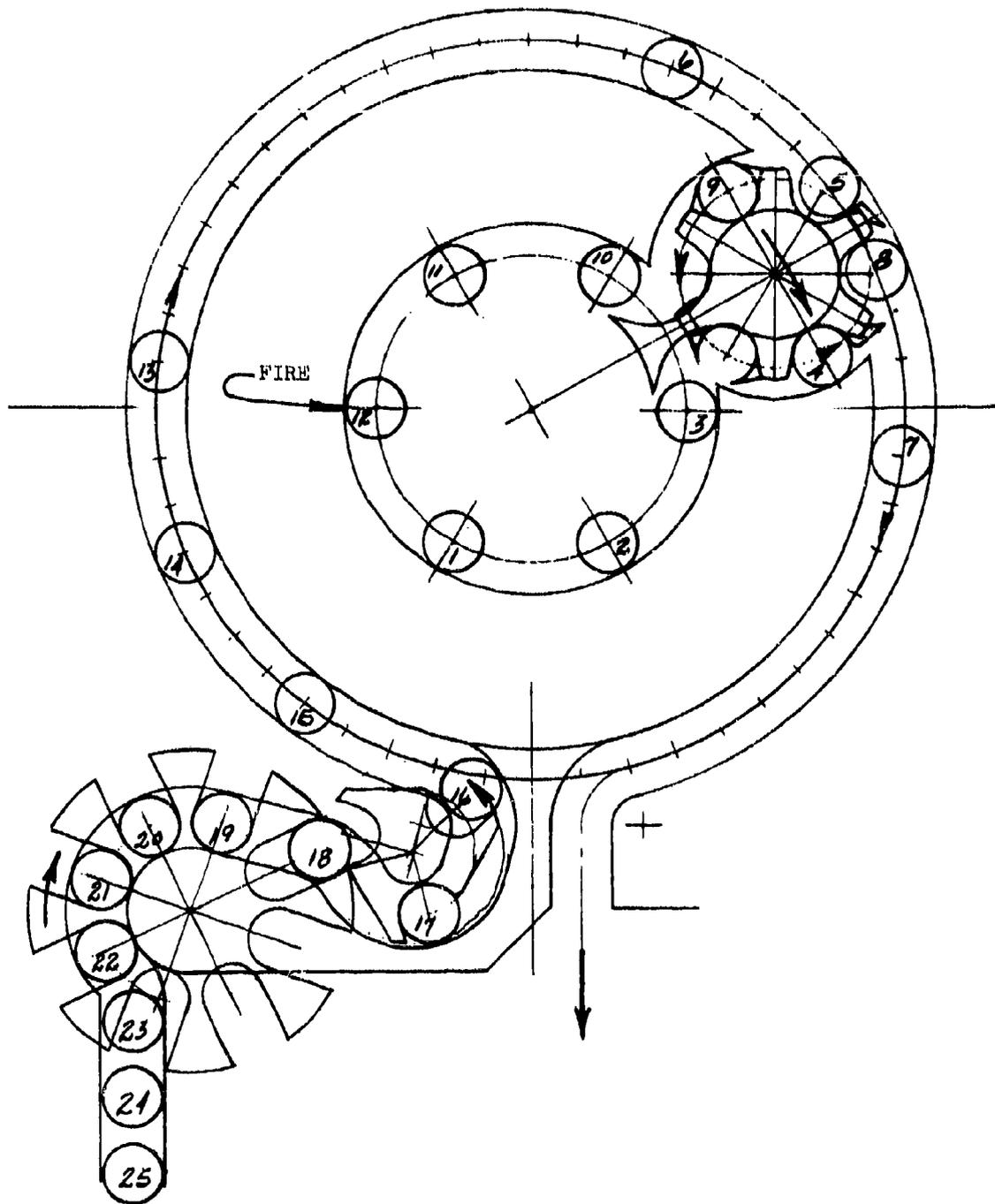


Figure I-16. Position 16: Round 16 Entering Squirrel Cage,
Round 12 Fired

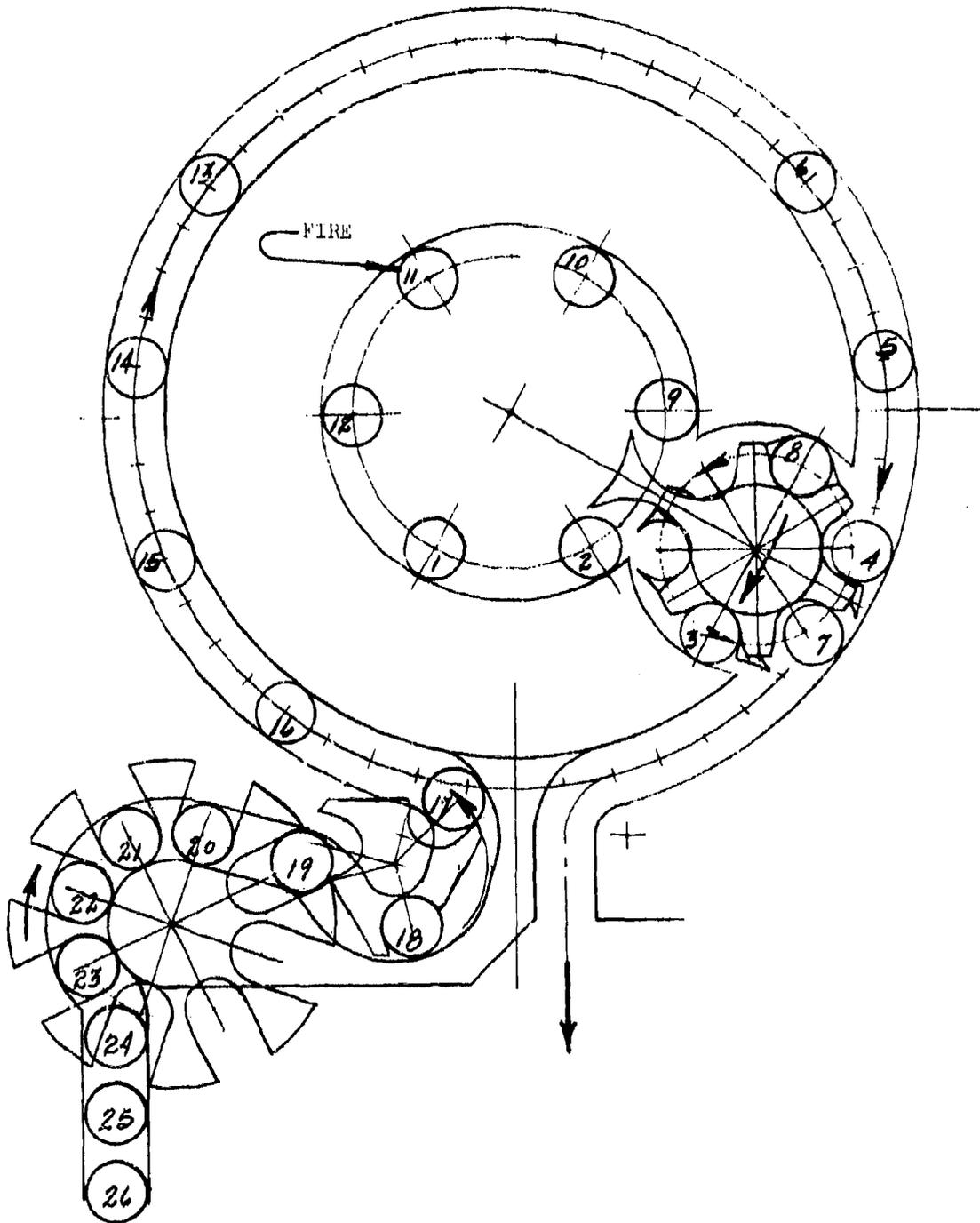


Figure I-17. Position 17: Round 17 Entering Squirrel Cage,
Round 11 Fired

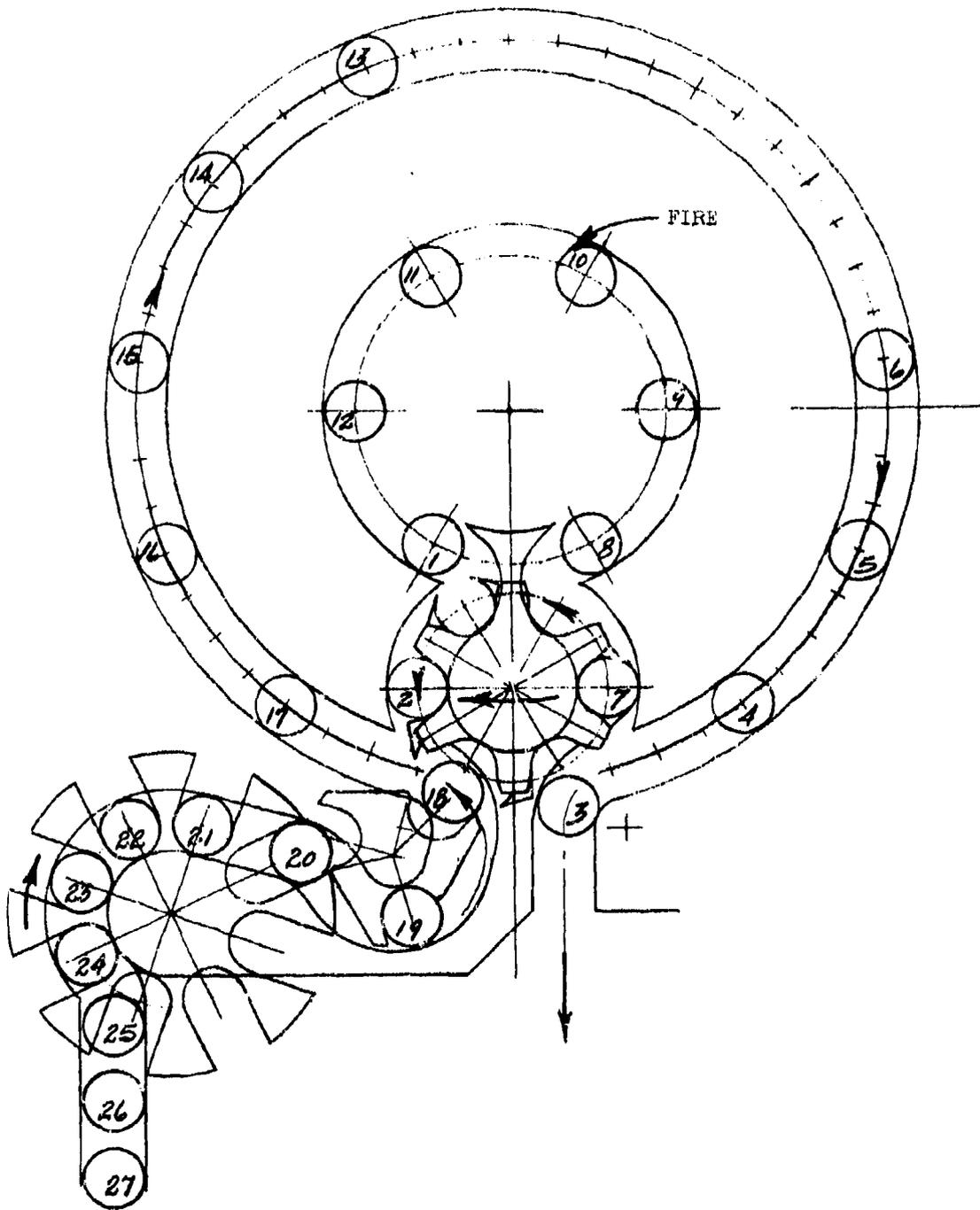


Figure I-18. Position 18: Round 18 Entering Squirrel Cage,
Round 10 Fired, Round 3 Being Ejected

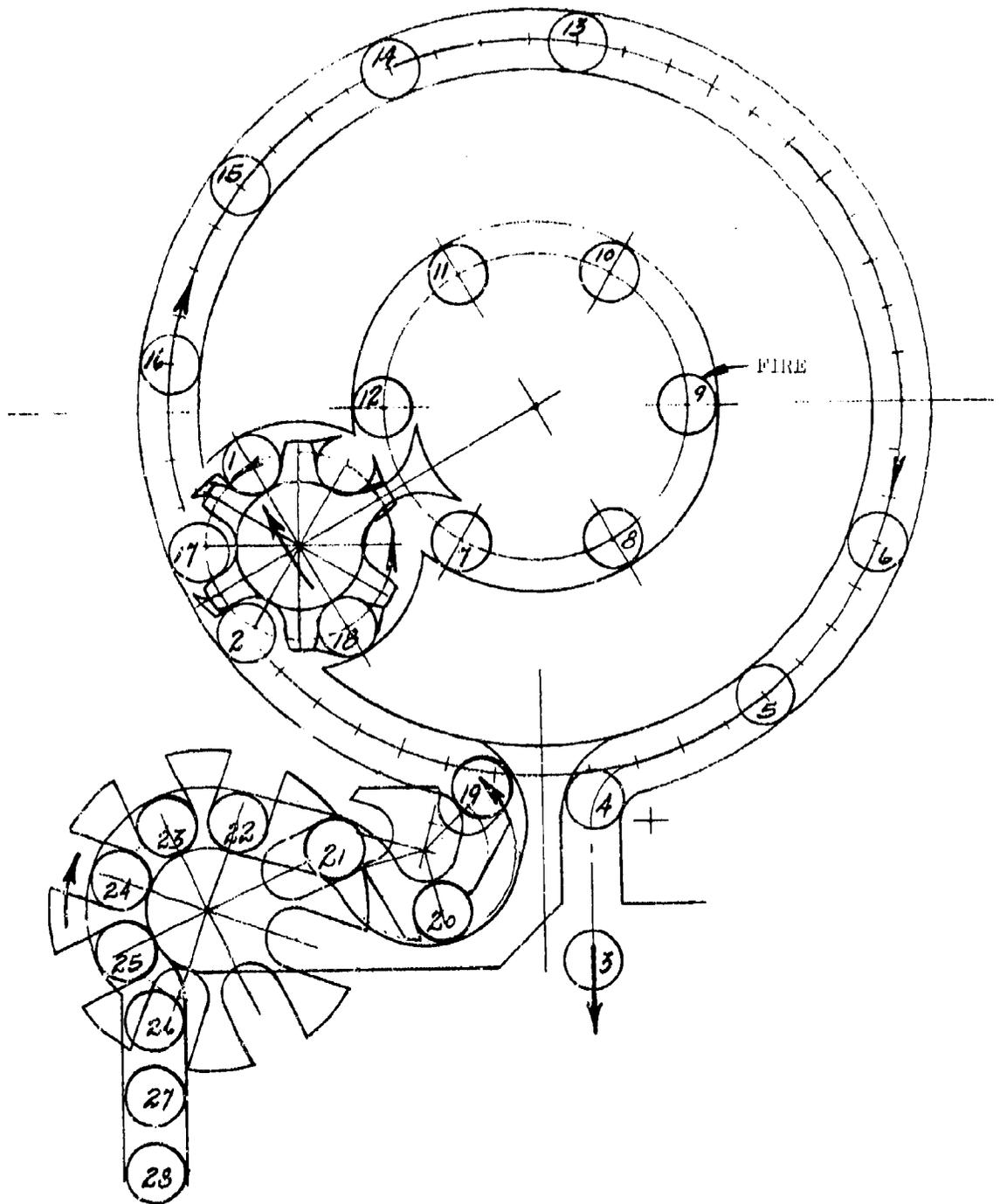


Figure I-19. Position 19: Round 19 Entering Squirrel Cage,
Round 9 Fired, Round 4 Being Ejected

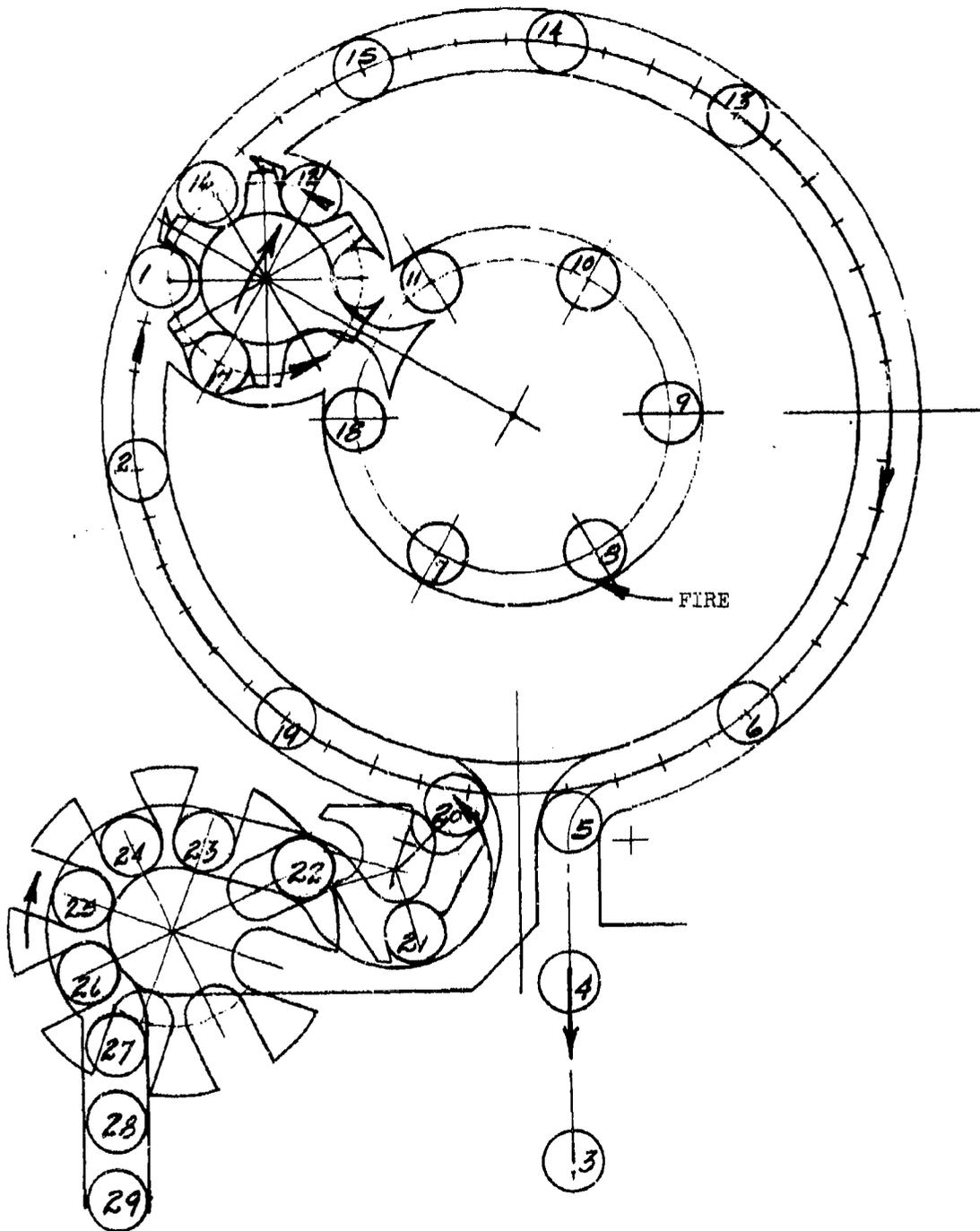


Figure I-20. Position 20: Round 20 Entering Squirrel Cage,
Round 8 Fired, Round 5 Being Ejected

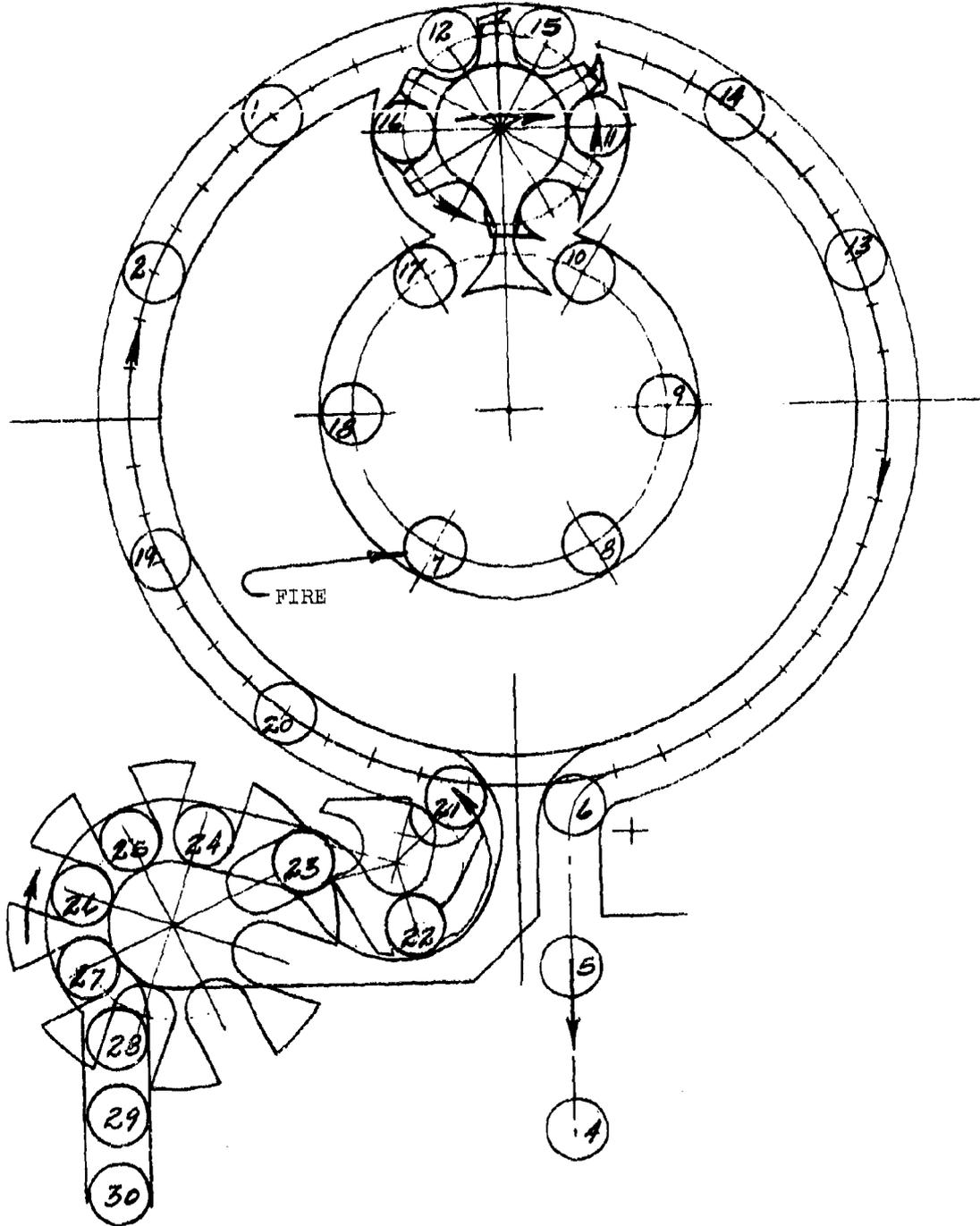


Figure I-21. Position 21: Round 21 Entering Squirrel Cage,
Round 7 Fired, Round 6 Being Ejected

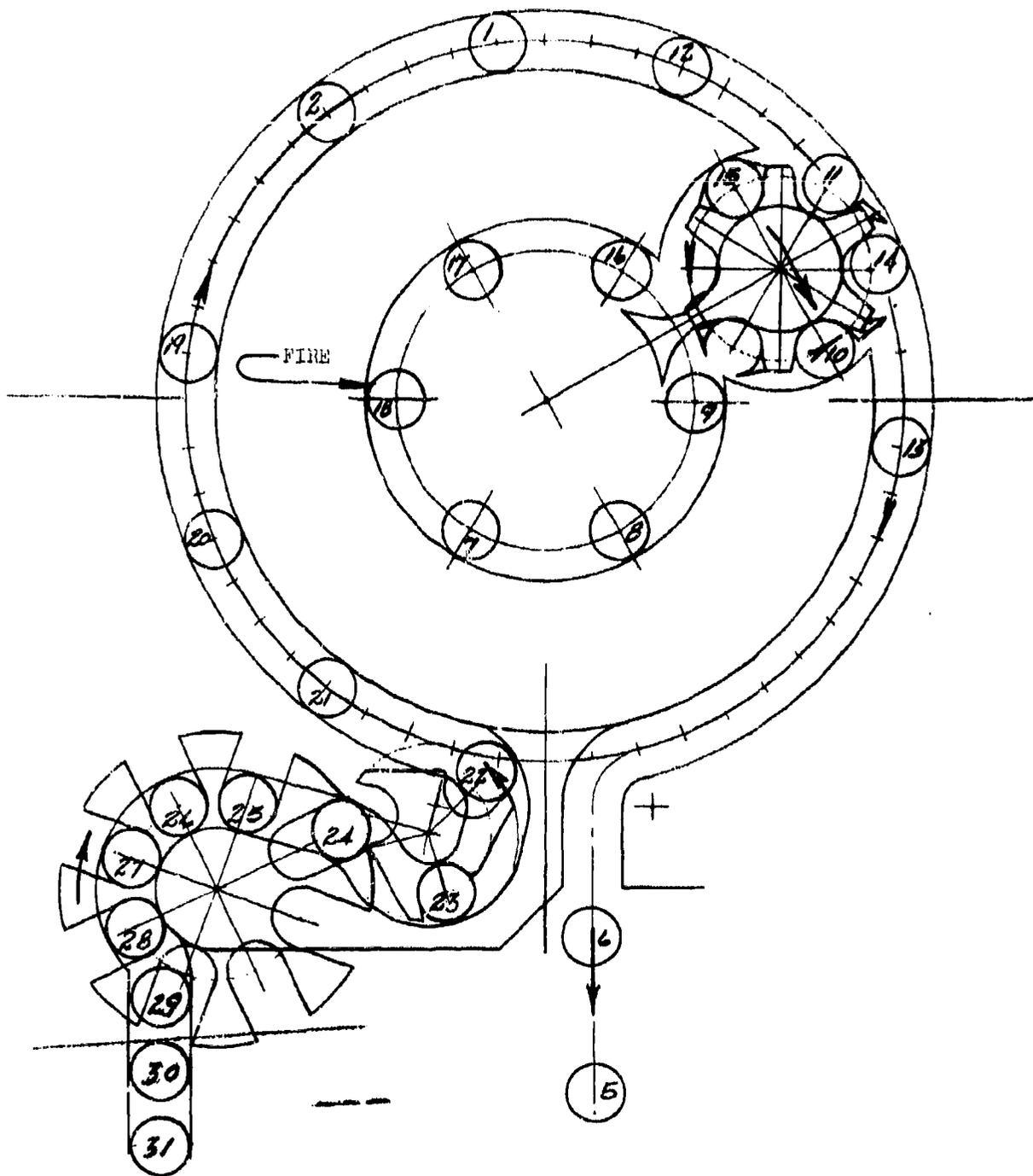


Figure I-22. Position 22: Round 22 Entering Squirrel Cage, Round 18 Fired

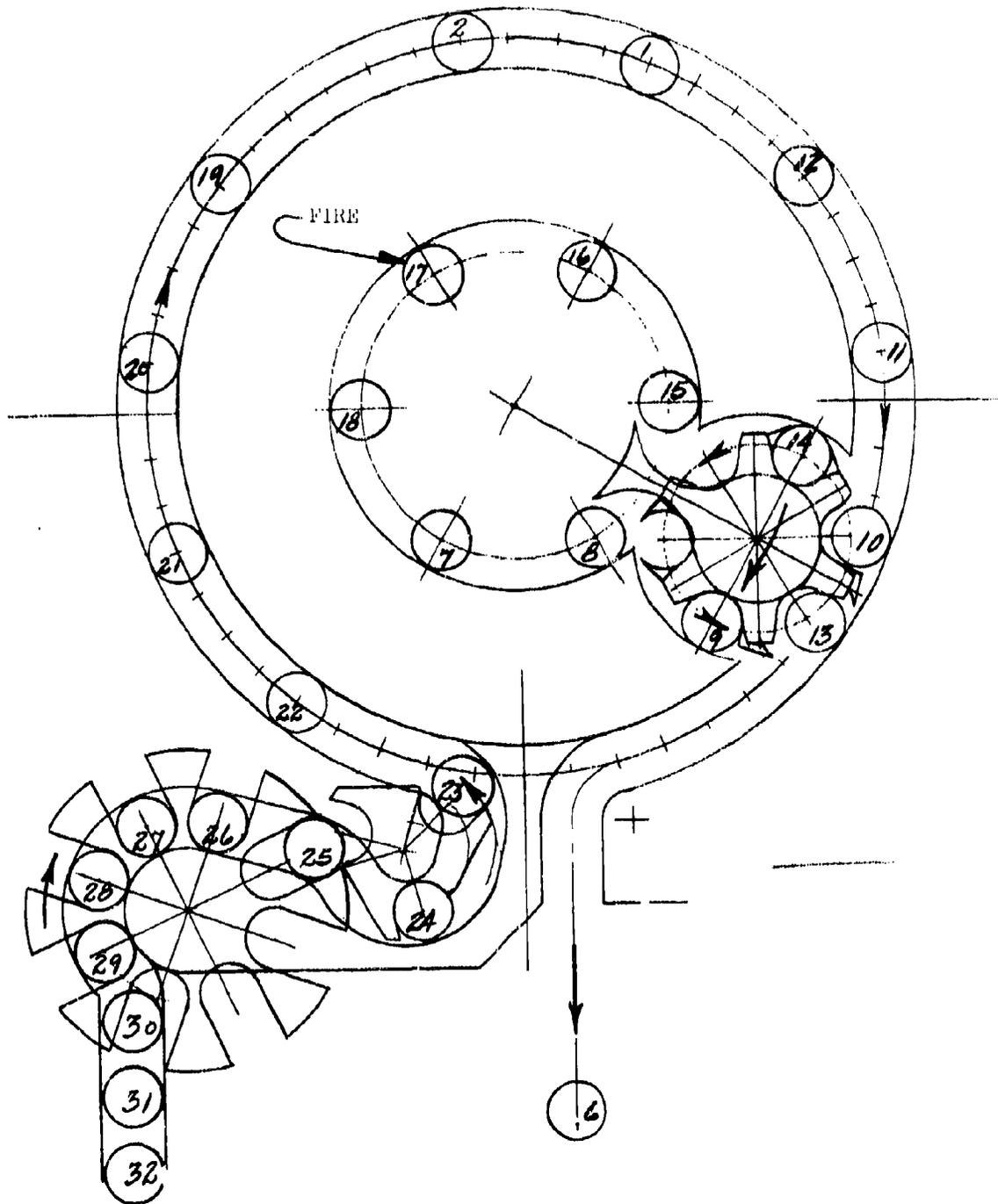


Figure I-23. Position 23: Round 23 Entering Squirrel Cage,
Round 17 Fired

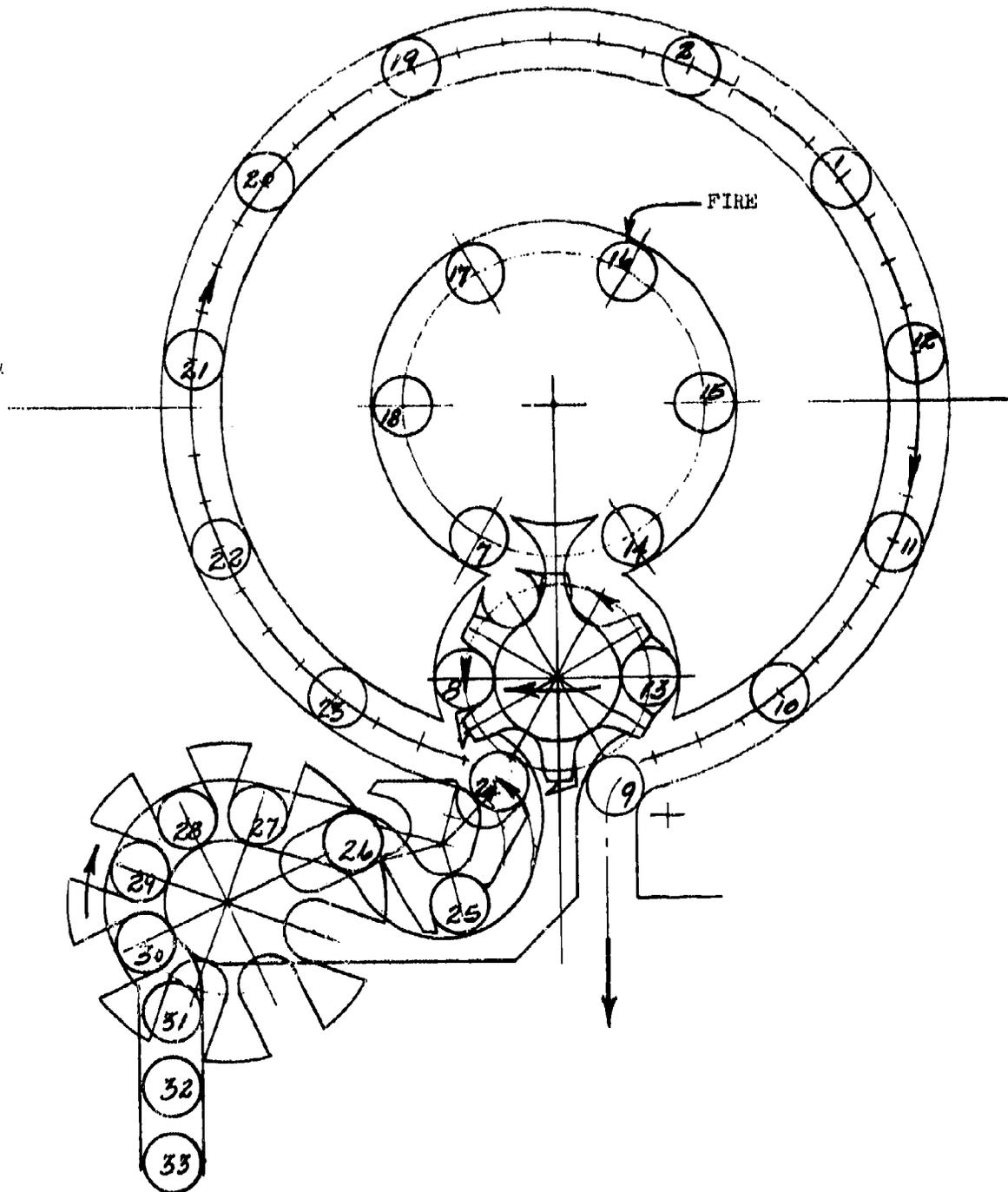


Figure I-24. Position 24: Round 24 Entering Squirrel Cage,
 Round 16 Fired, Round 9 Being Ejected

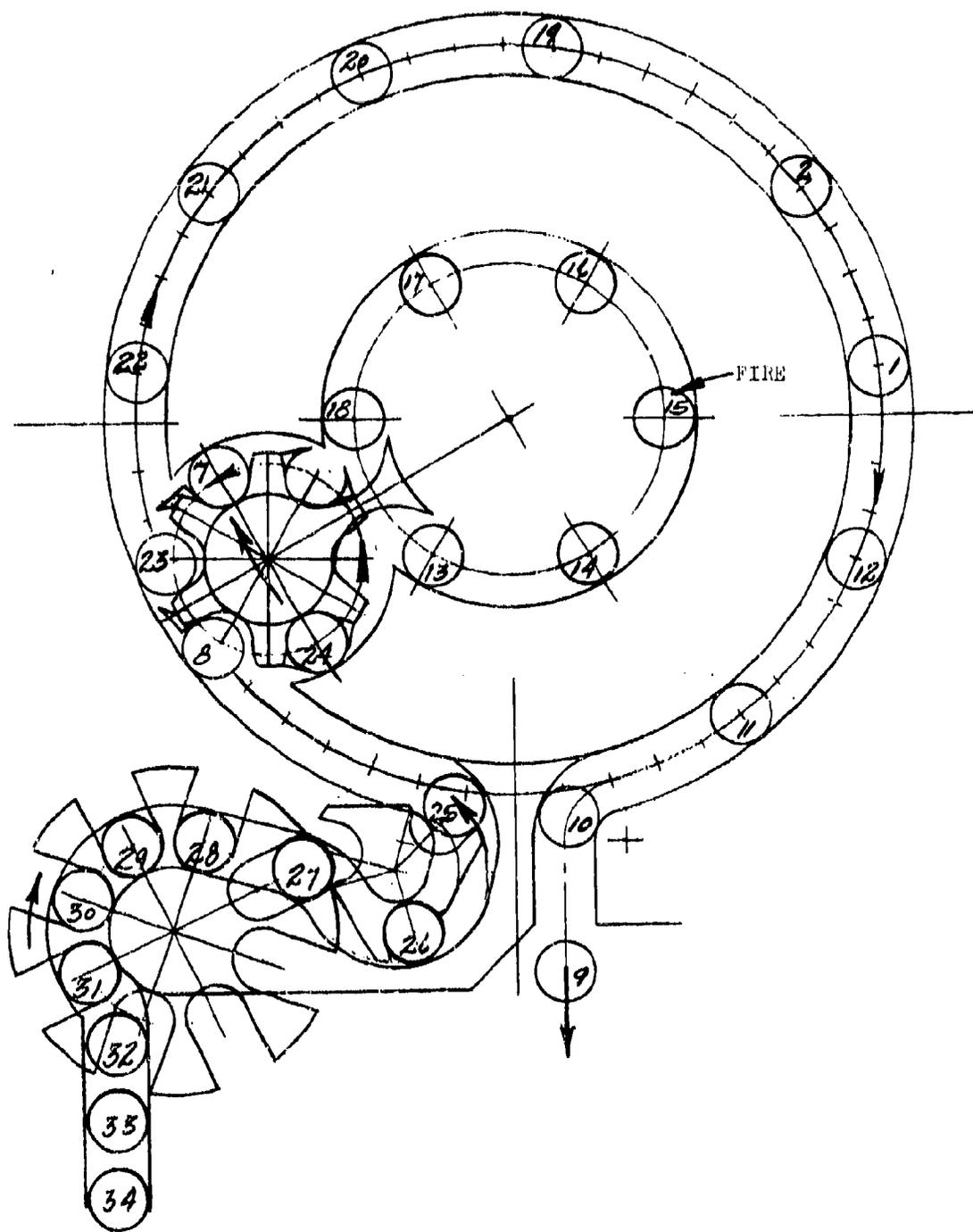


Figure I-25. Position 25: Round 25 Entering Squirrel Cage,
 Round 15 Fired, Round 10 Being Ejected

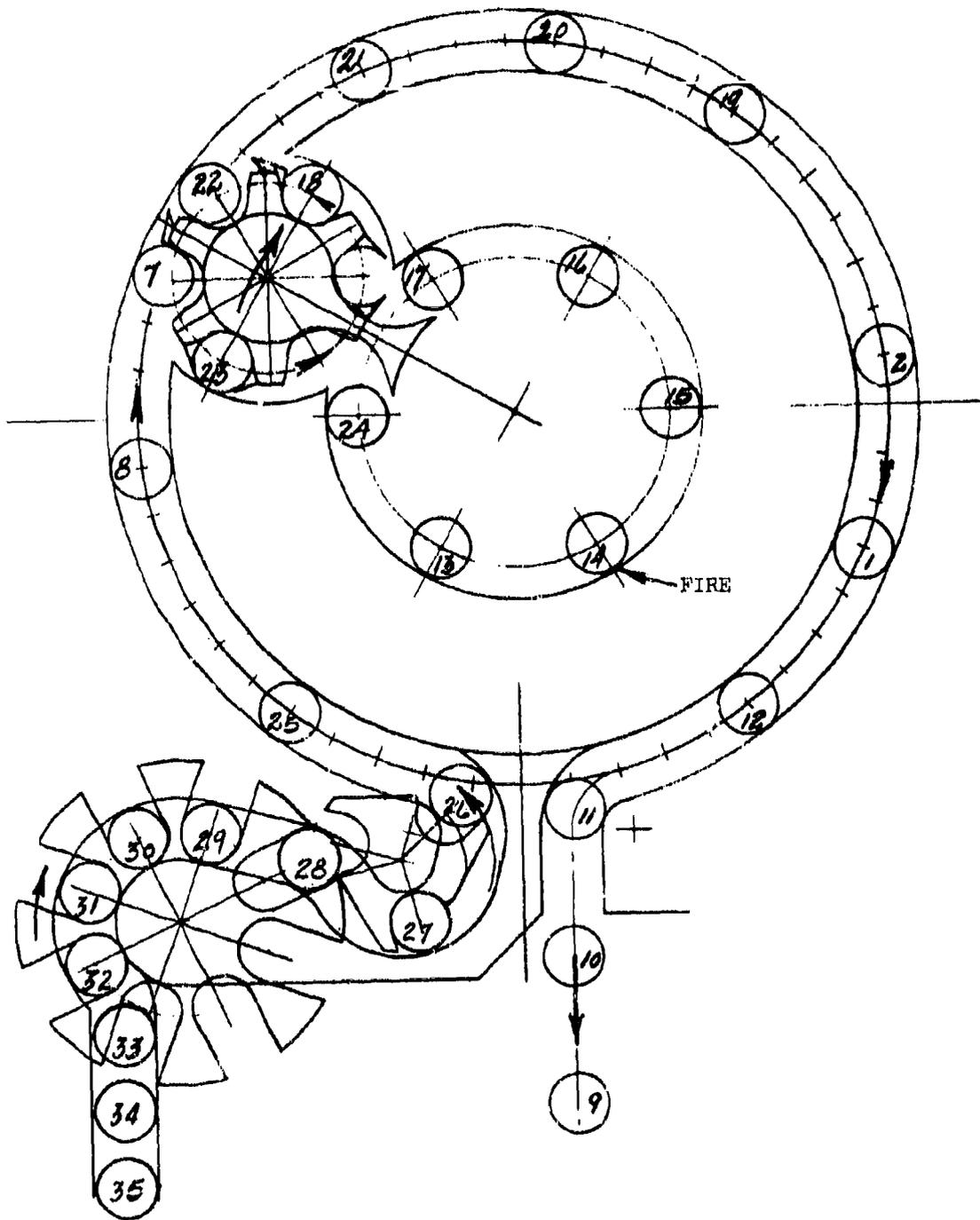


Figure I-26. Position 26: Round 26 Entering Squirrel Cage,
Round 14 Fired, Round 11 Being Ejected

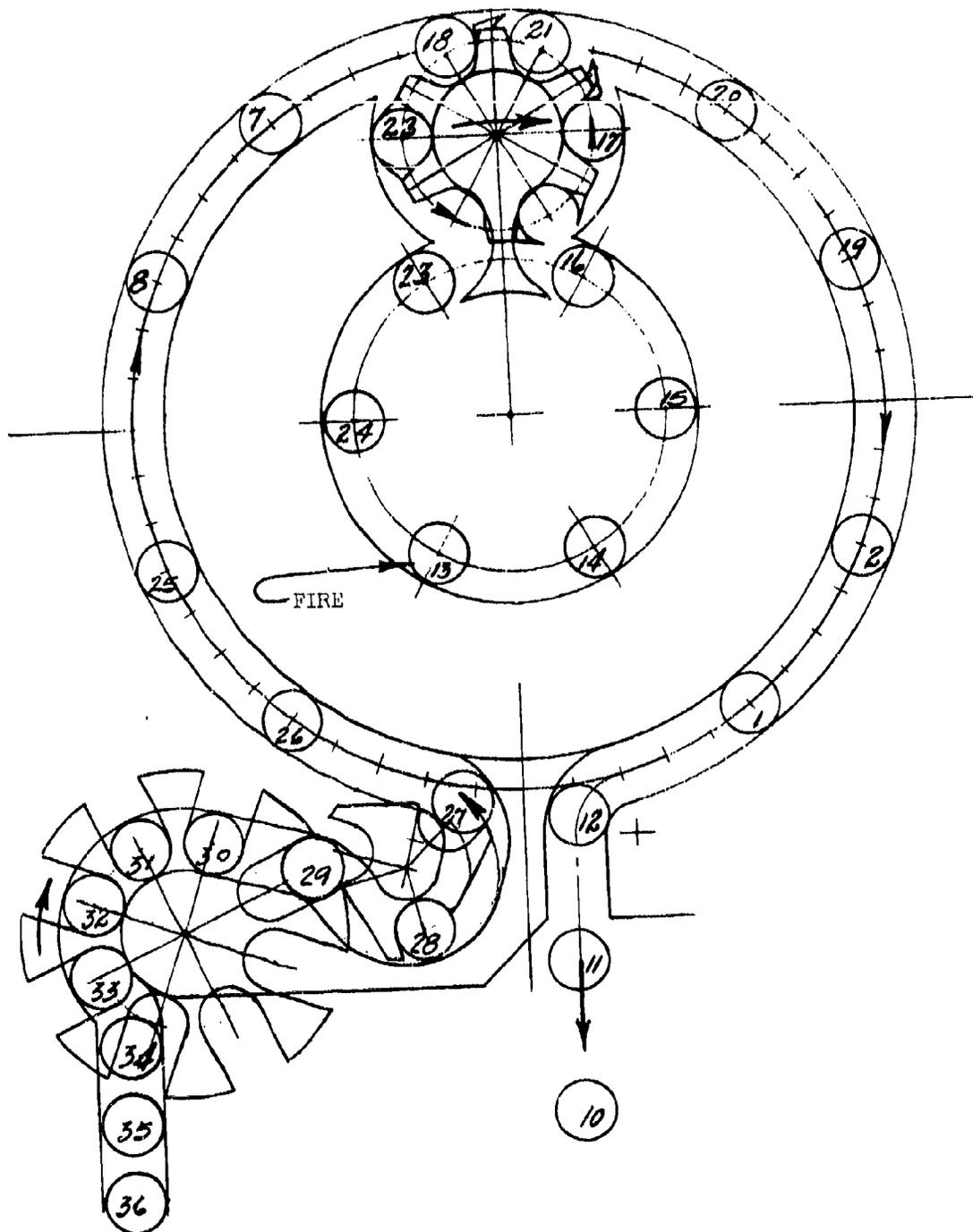


Figure I-27. Position 27: Round 27 Entering Squirrel Cage, Round 13 Fired, Round 12 Being Ejected

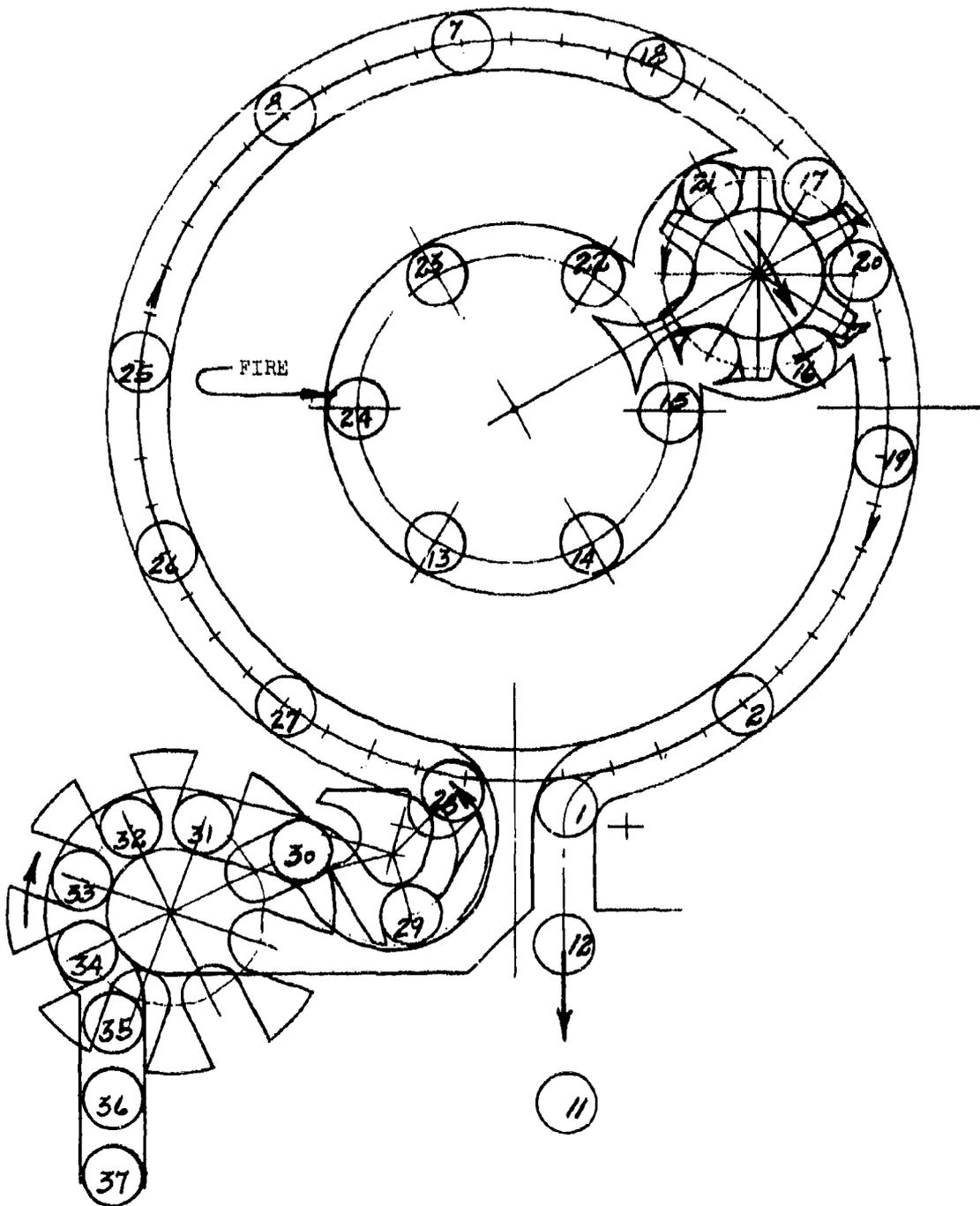


Figure I-28. Position 28: Round 28 Entering Squirrel Cage,
Round 24 Fired, Round 1 Being Ejected

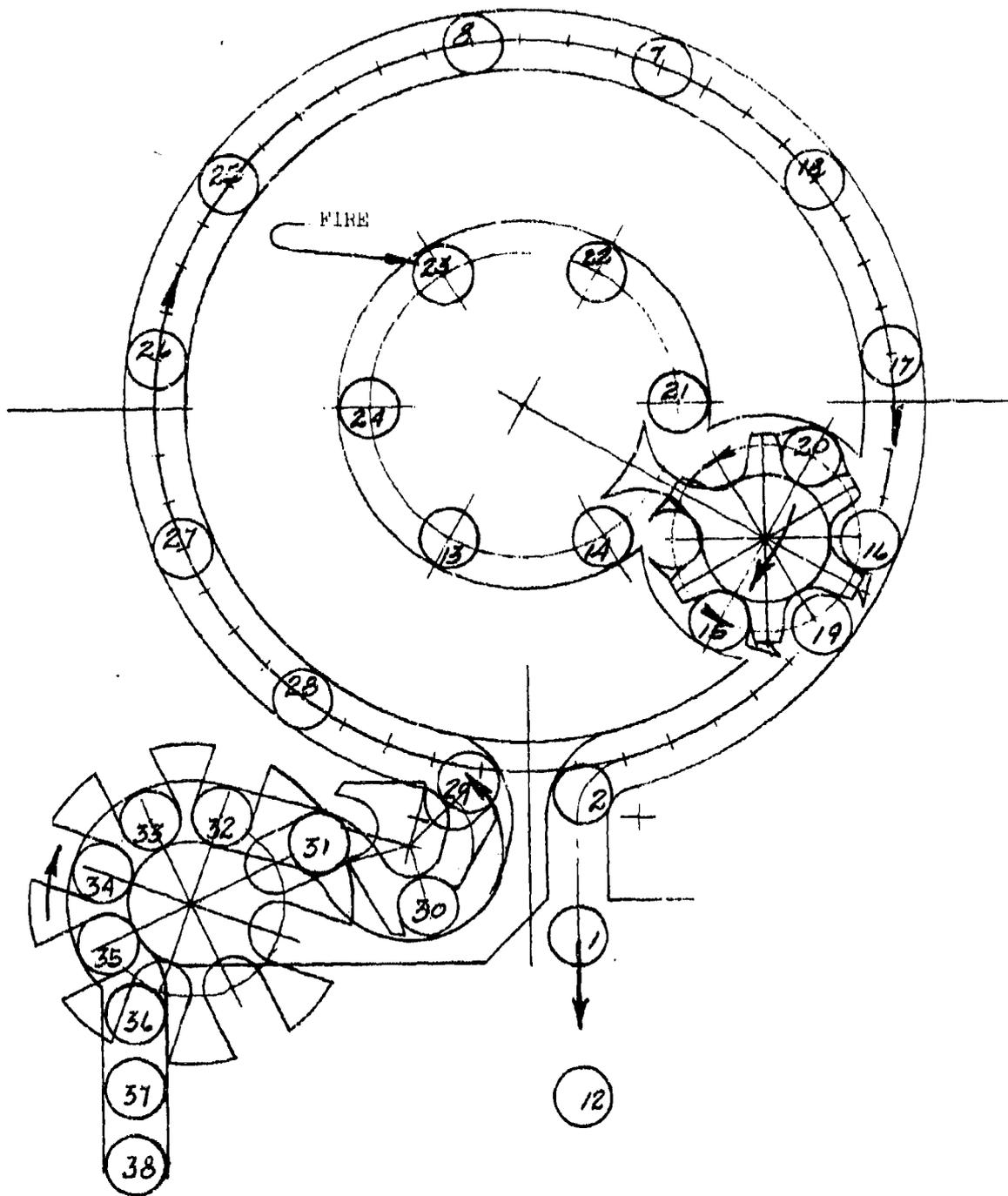


Figure I-29. Position 29: Round 29 Entering Squirrel Cage,
 Round 23 Fired, Round 2 Being Ejected

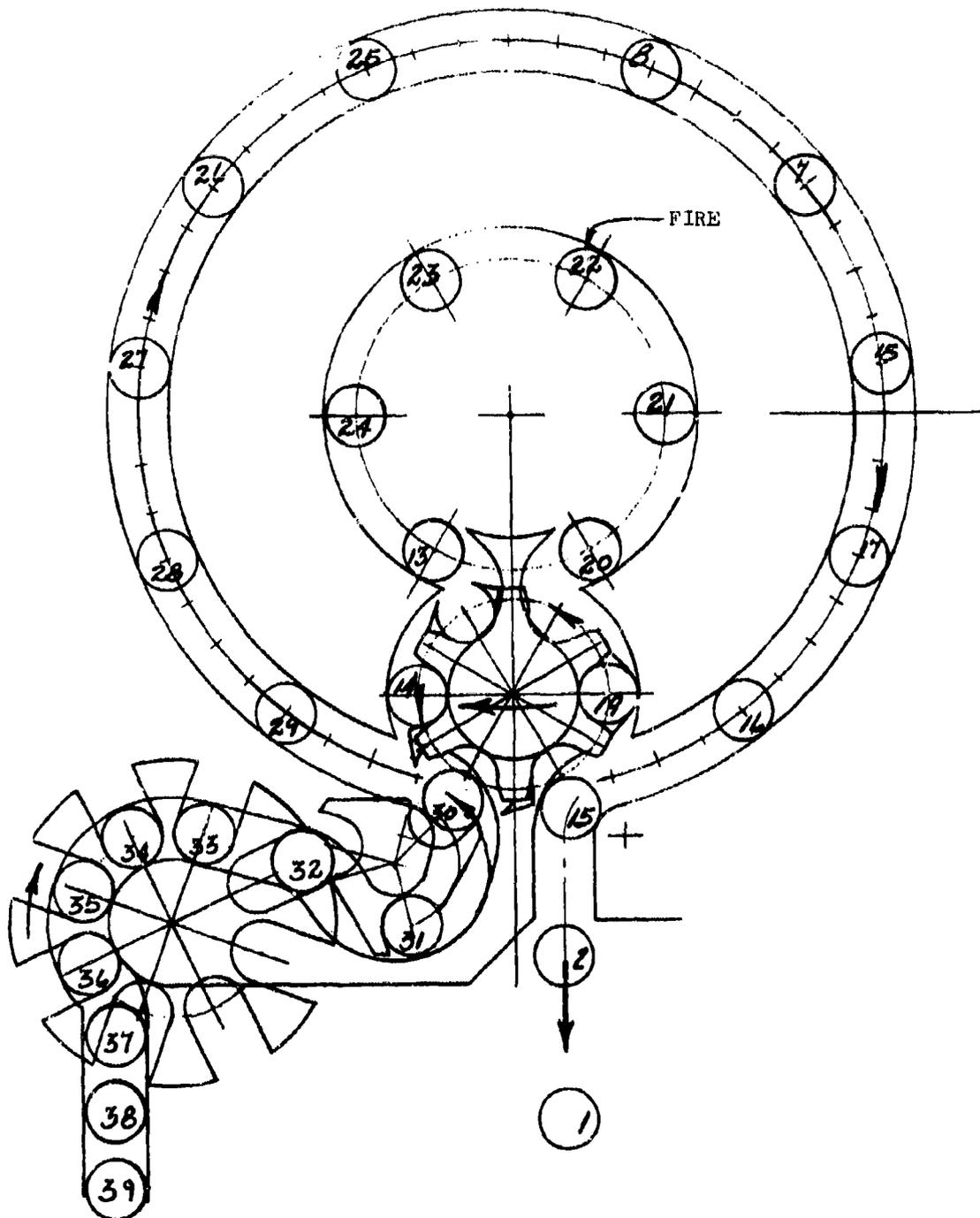


Figure I-30. Position 30: Round 30 Entering Squirrel Cage,
 Round 22 Fired, Round 15 Being Ejected

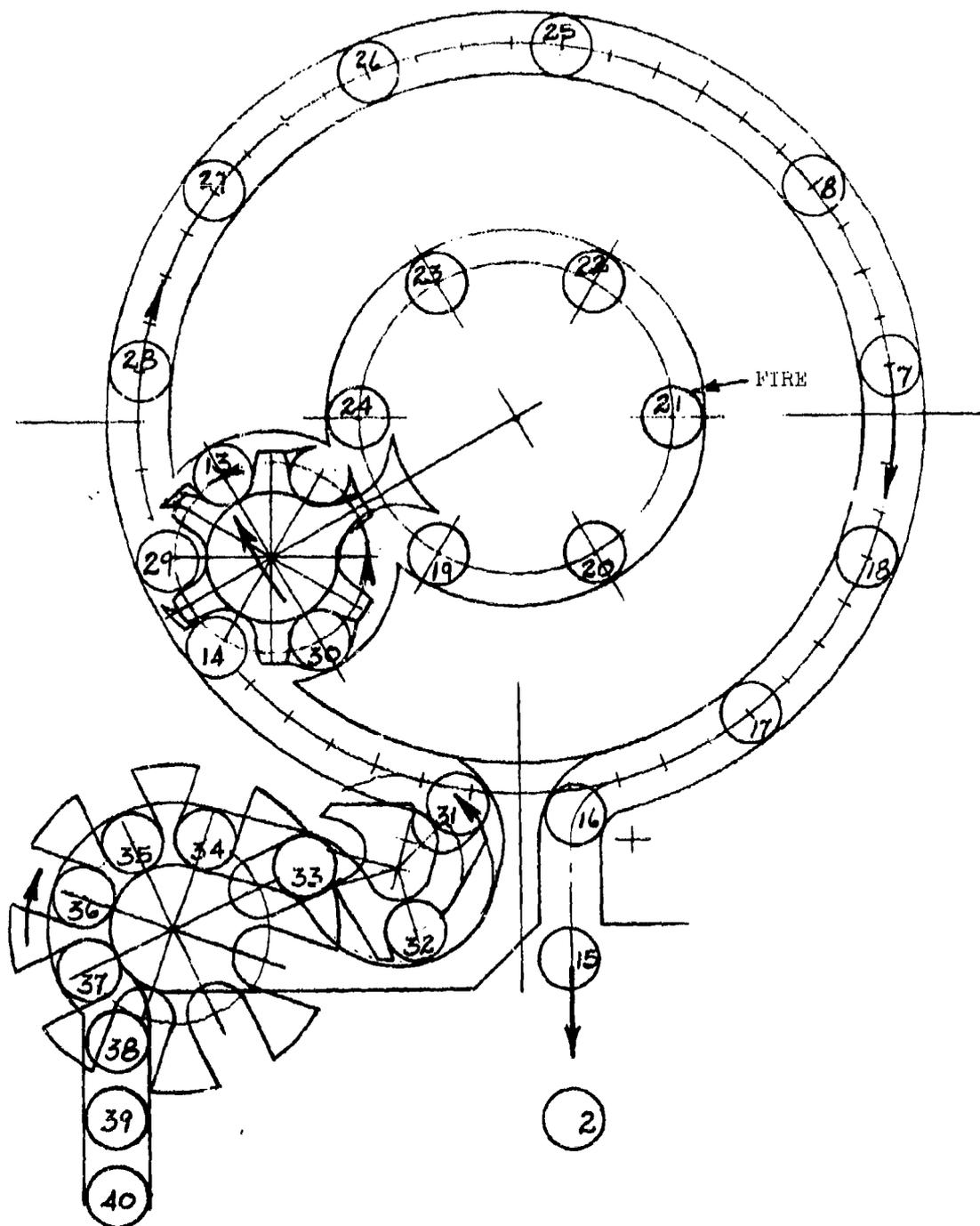


Figure I-31. Position 31: Round 31 Entering Squirrel Cage,
Round 21 Fired, Round 16 Being Ejected

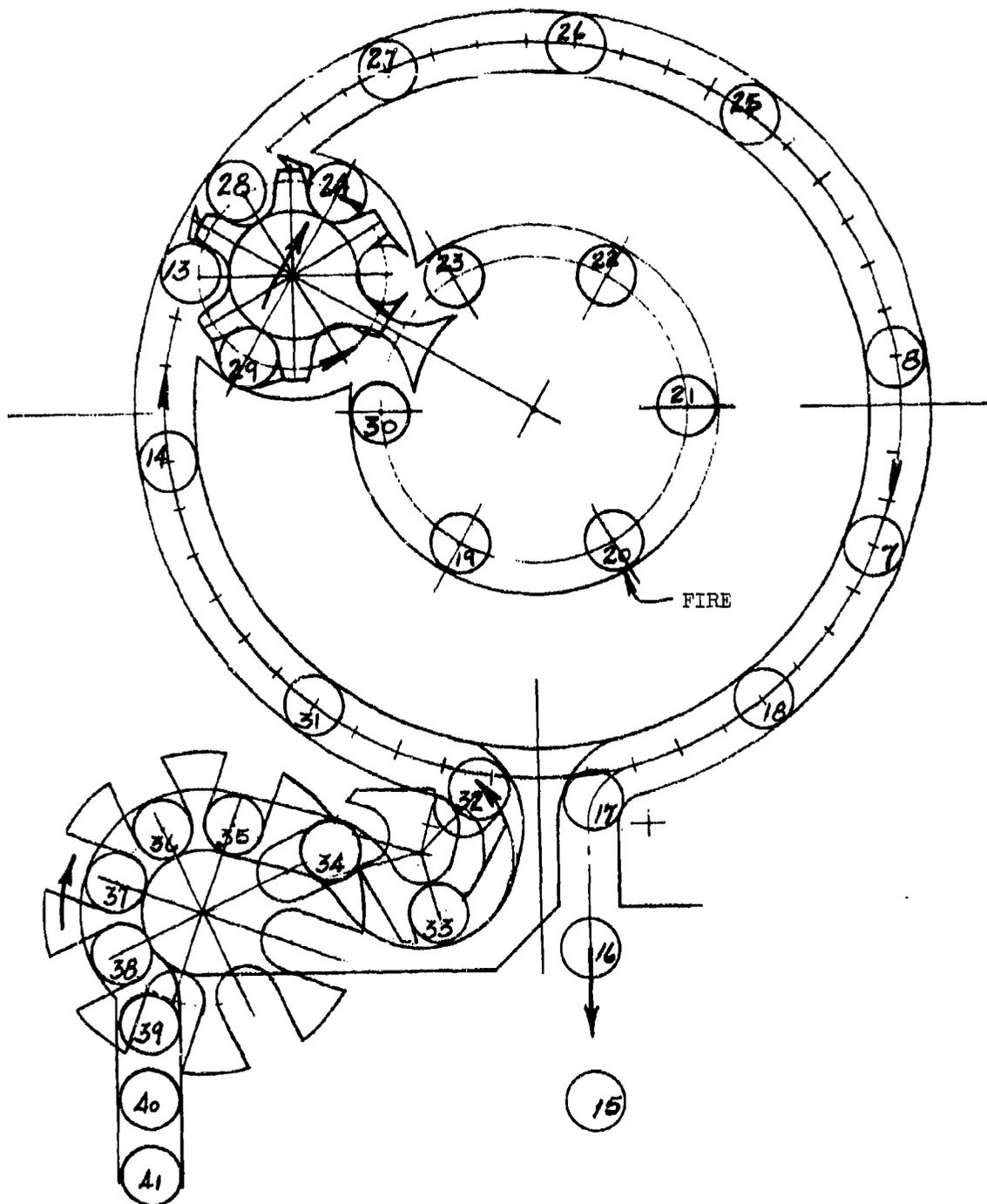


Figure I-32. Position 32: Round 32 Entering Squirrel Cage,
Round 20 Fired, Round 17 Being Ejected

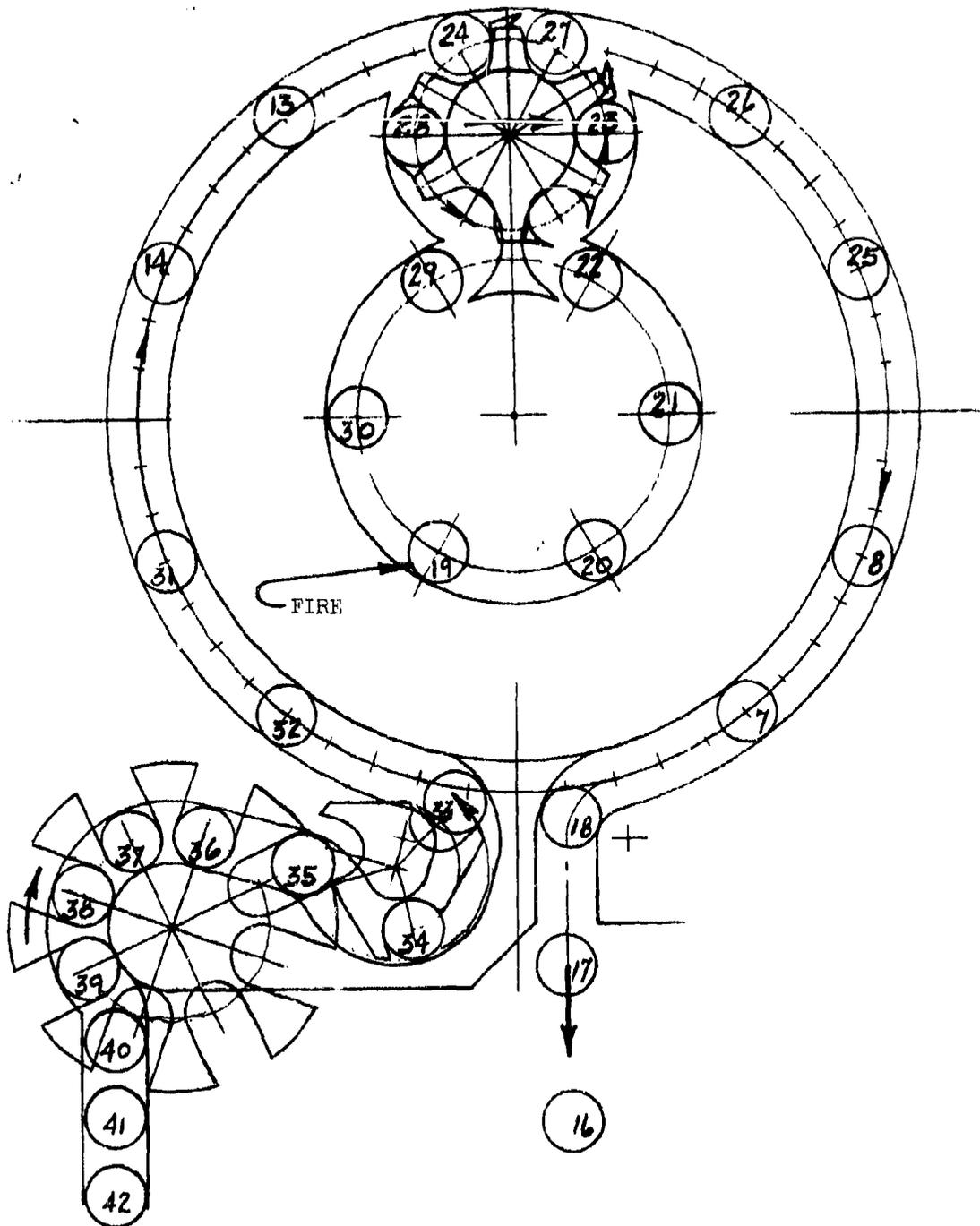


Figure I-33. Position 33: Round 33 Entering Squirrel Cage,
Round 19 Fired, Round 18 Being Ejected

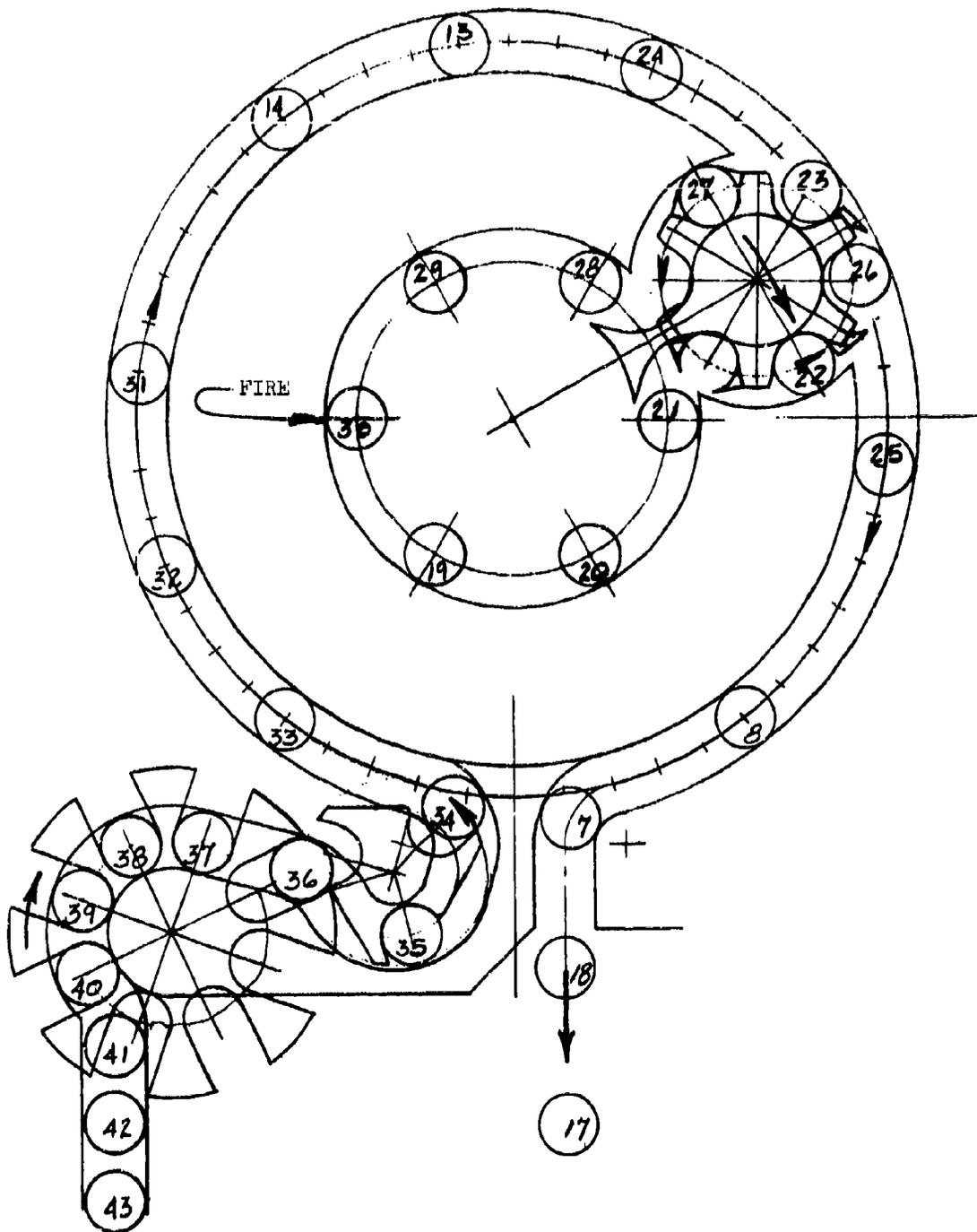


Figure I-34. Position 34: Round 34 Entering Squirrel Cage,
Round 30 Fired, Round 7 Being Ejected

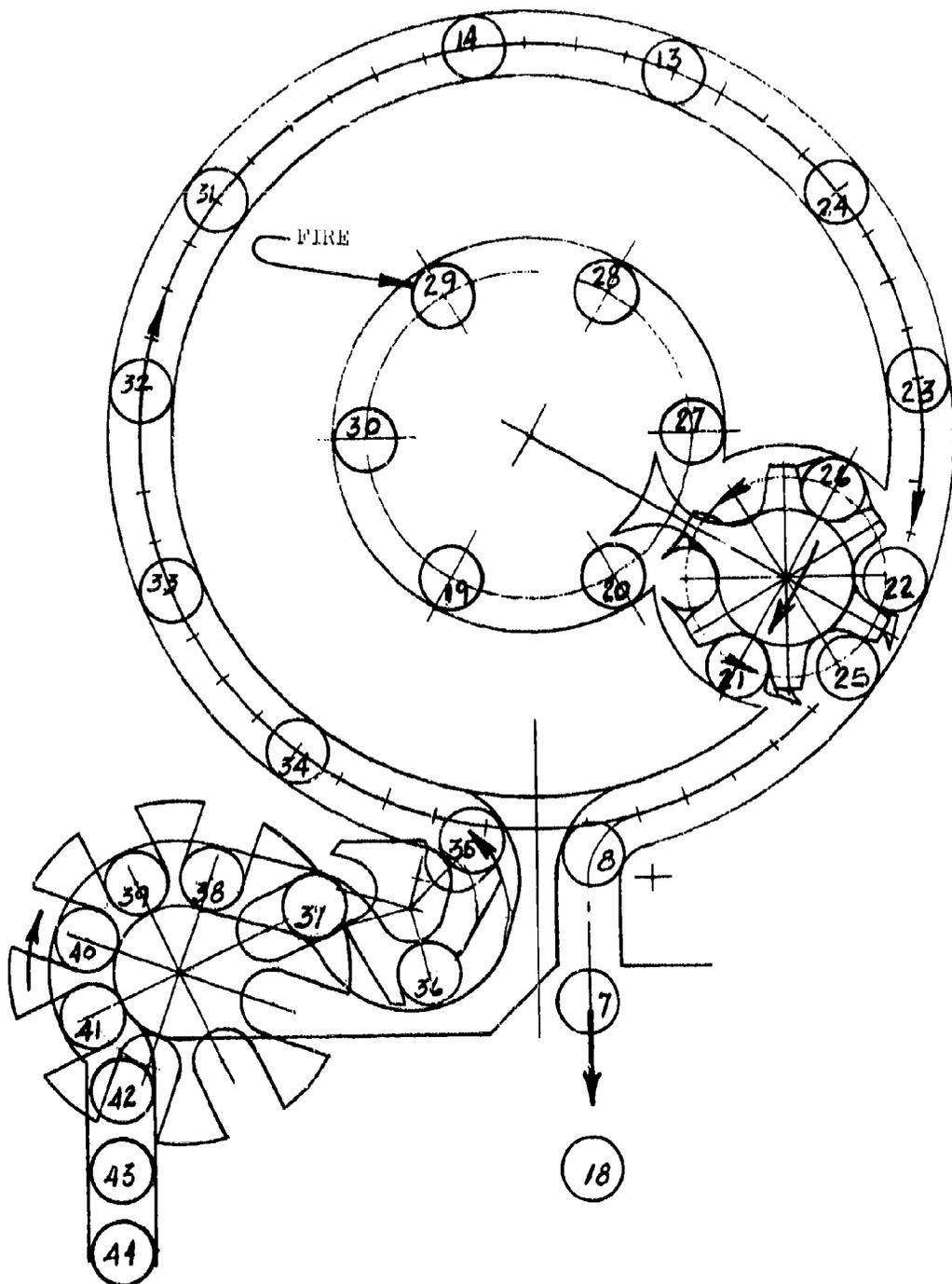


Figure I-35. Position 35: Round 35 Entering Squirrel Cage, Round 29 Fired, Round 8 Being Ejected

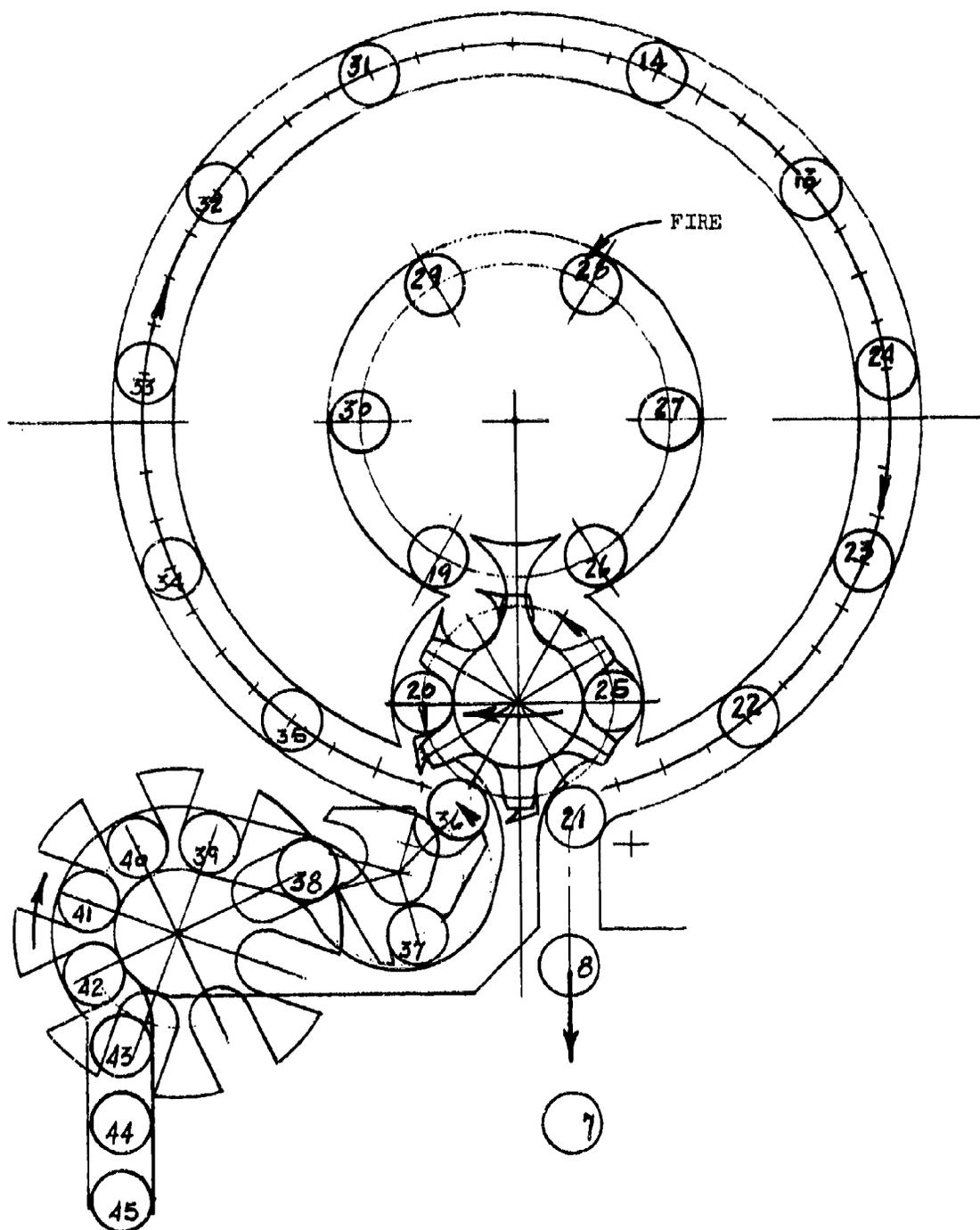


Figure I-36. Position 36: Round 36 Entering Squirrel Cage,
Round 28 Fired, Round 21 Being Ejected

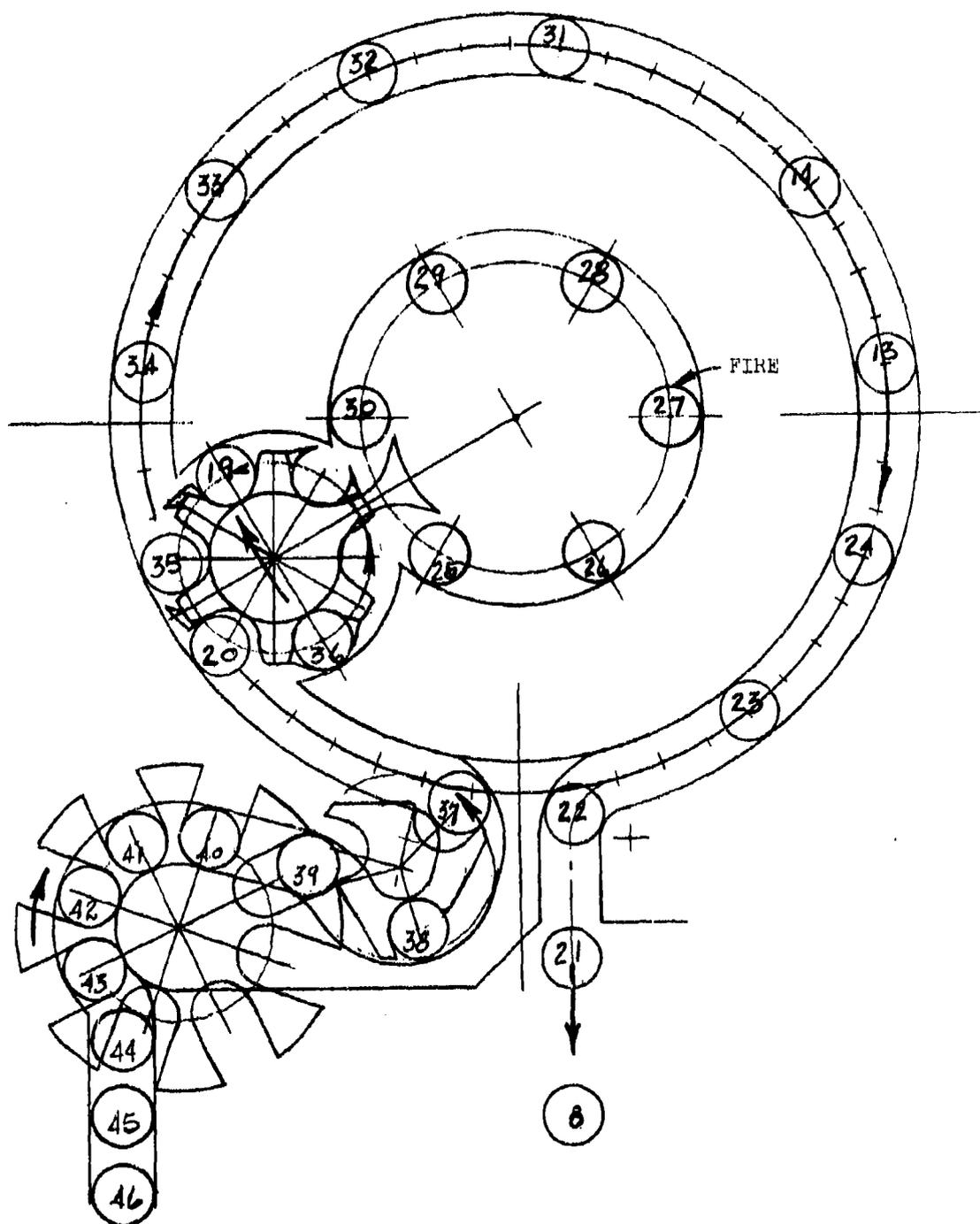


Figure I-37. Position 37: Round 37 Entering Squirrel Cage, Round 27 Fired, Round 22 Being Ejected

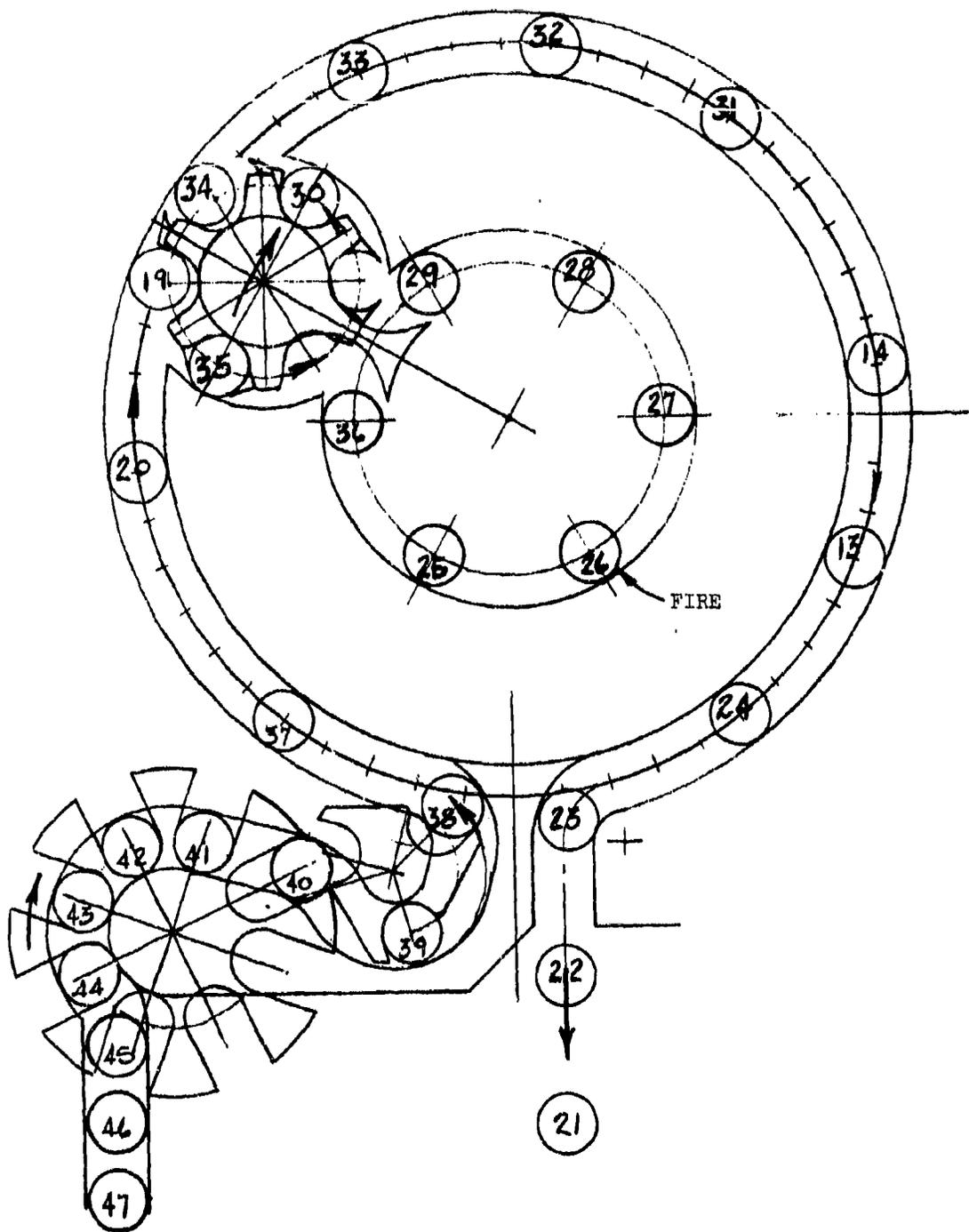


Figure I-38. Position 38: Round 38 Entering Squirrel Cage,
 Round 26 Fired, Round 23 Being Ejected

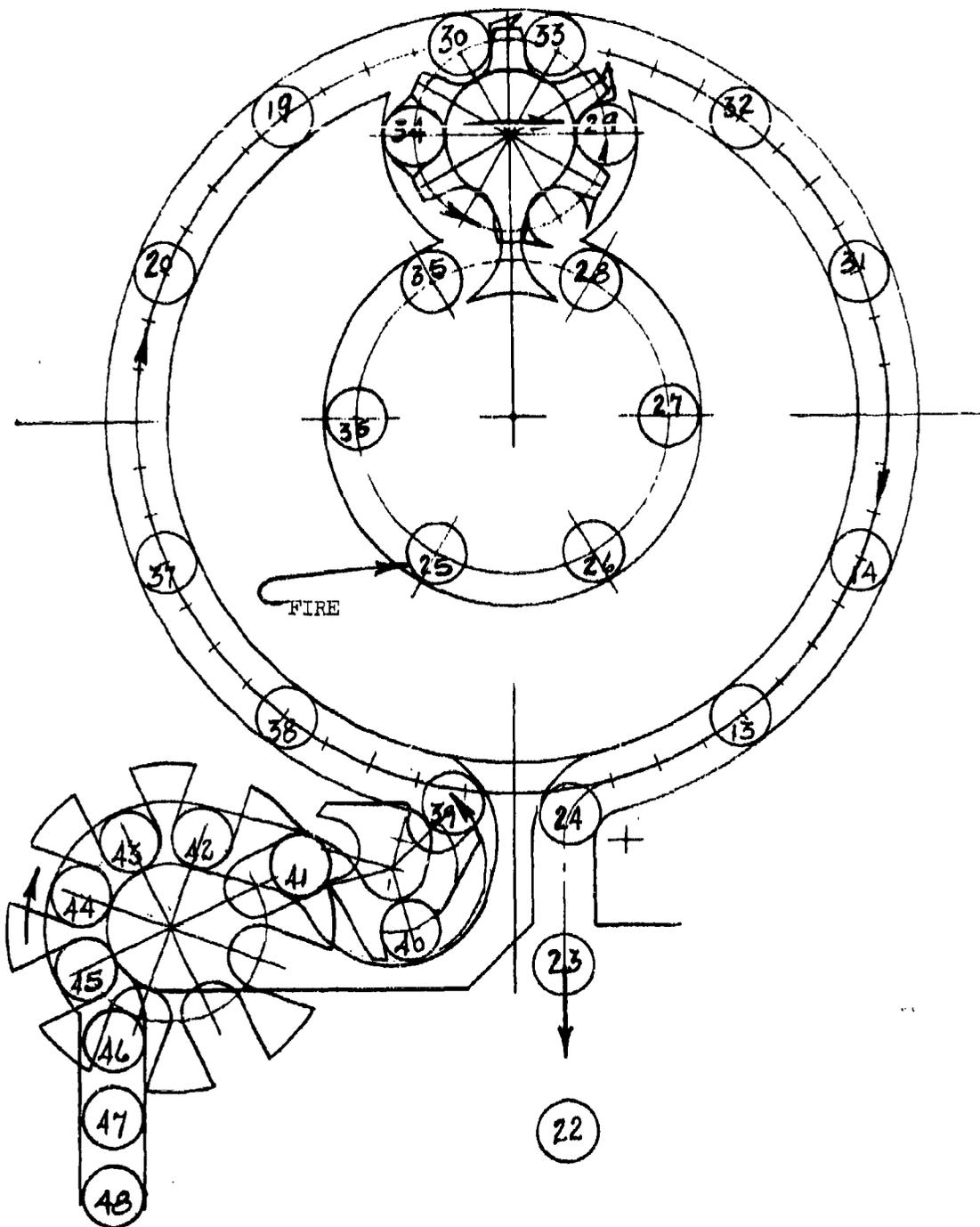


Figure I-39. Position 39: Round 39 Entering Squirrel Cage,
Round 25 Fired, Round 24 Being Ejected

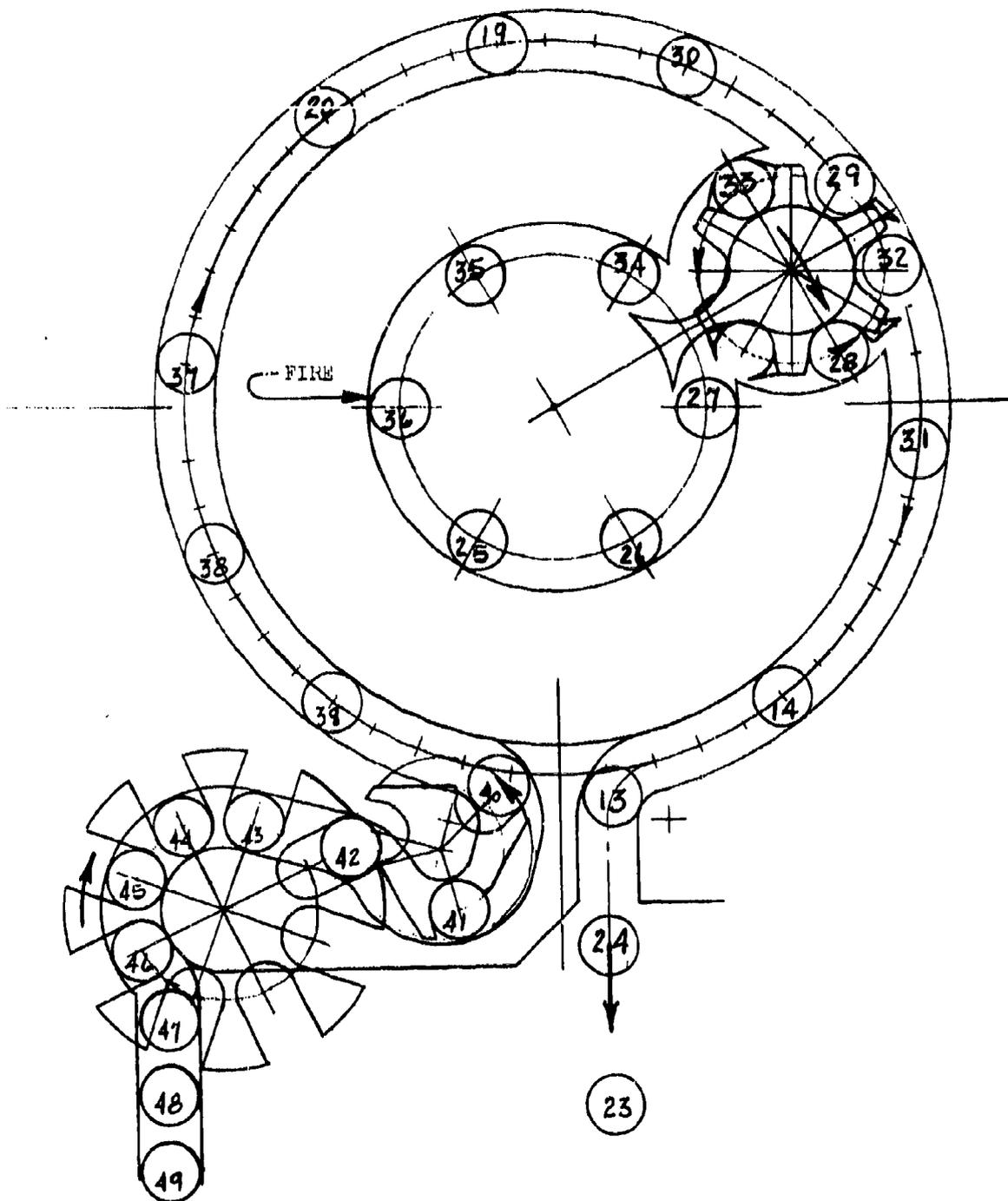


Figure I-40. Position 40: Round 40 Entering Squirrel Cage,
 Round 36 Fired, Round 13 Being Ejected

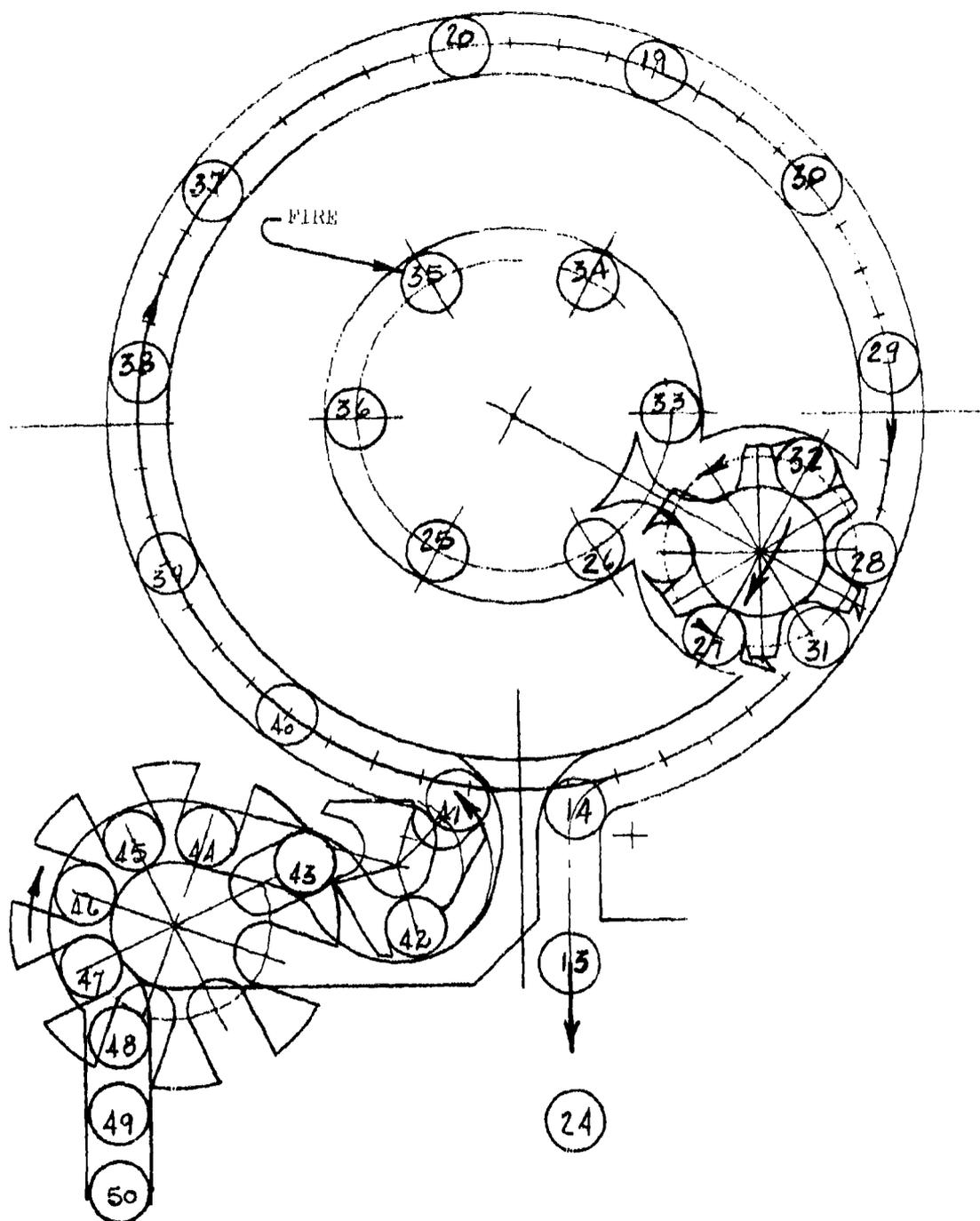


Figure I-41. Position 41: Round 41 Entering Squirrel Cage,
Round 35 Fired, Round 14 Being Ejected

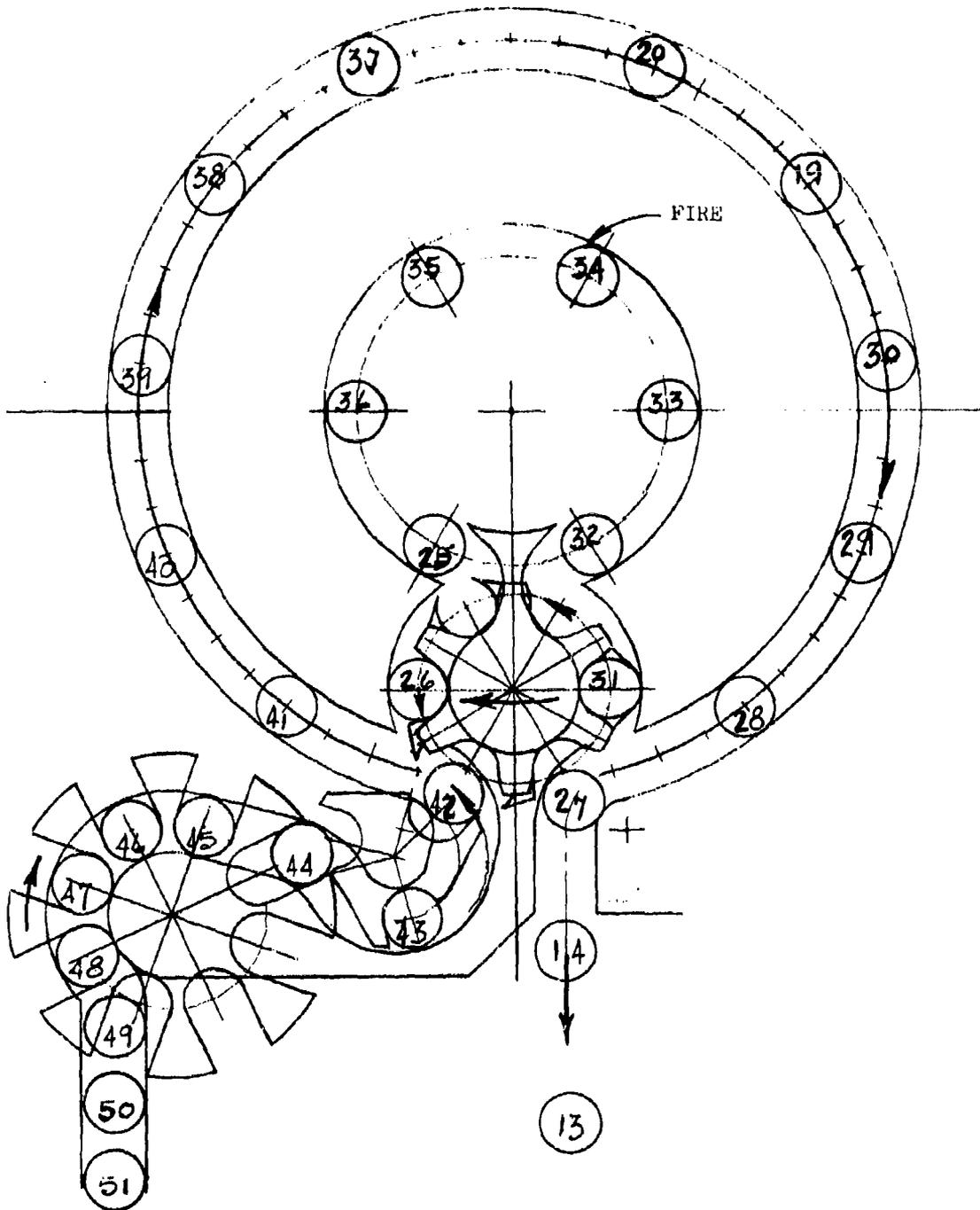


Figure I-42. Position 42: Round 42 Entering Squirrel Cage,
 Round 34 Fired, Round 27 Being Ejected

APPENDIX II

PHOTOGRAPHS TO ILLUSTRATE MAJOR SUBASSEMBLIES AND DETAILS OF THE WEAPON SYSTEM

A series of photographs are presented in this appendix to illustrate the major subassemblies and details of the weapon system. (See Figures II-1 through II-17.)

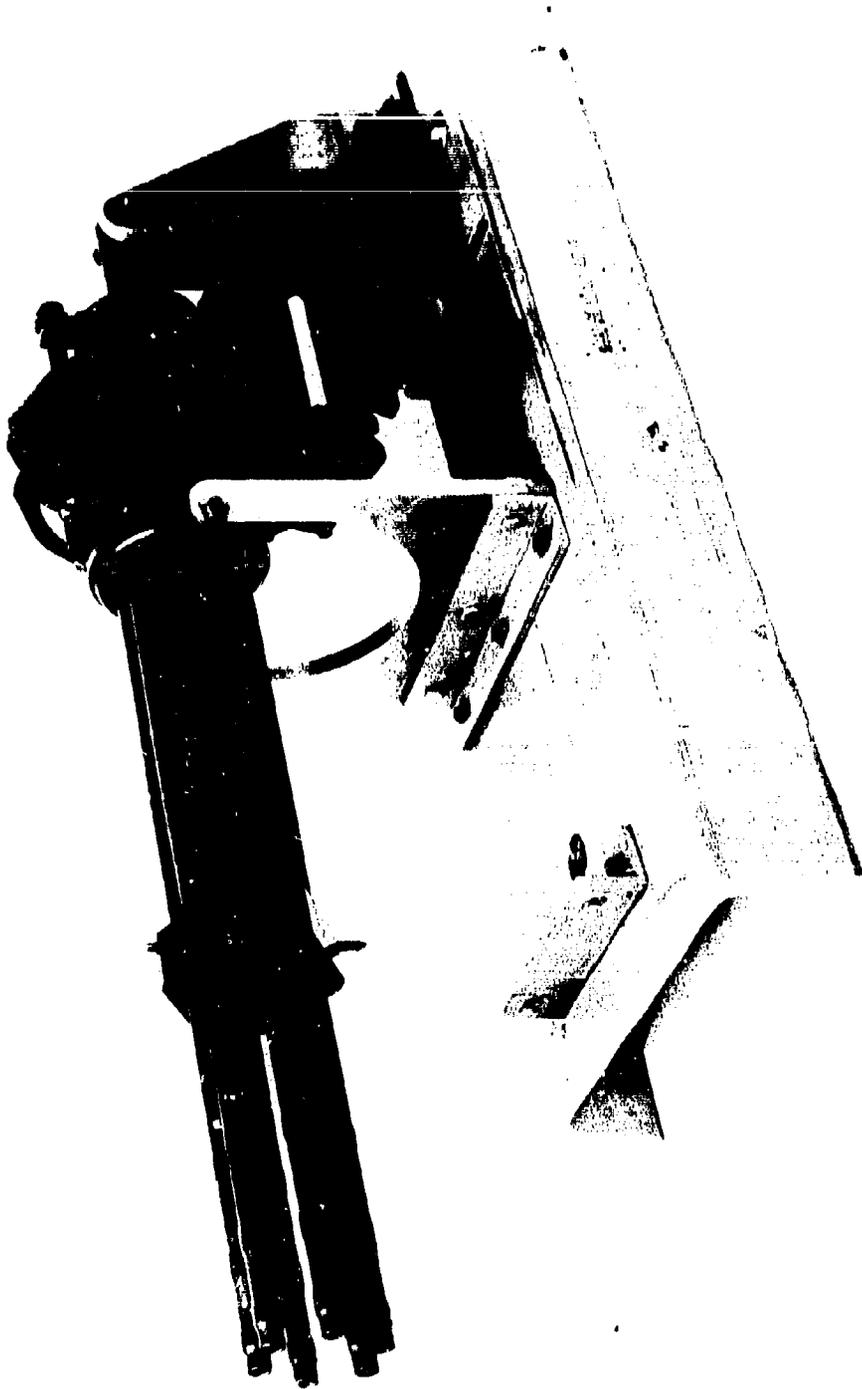


Figure II-1. Nonrotating Externally Powered Gun in Firing Mount

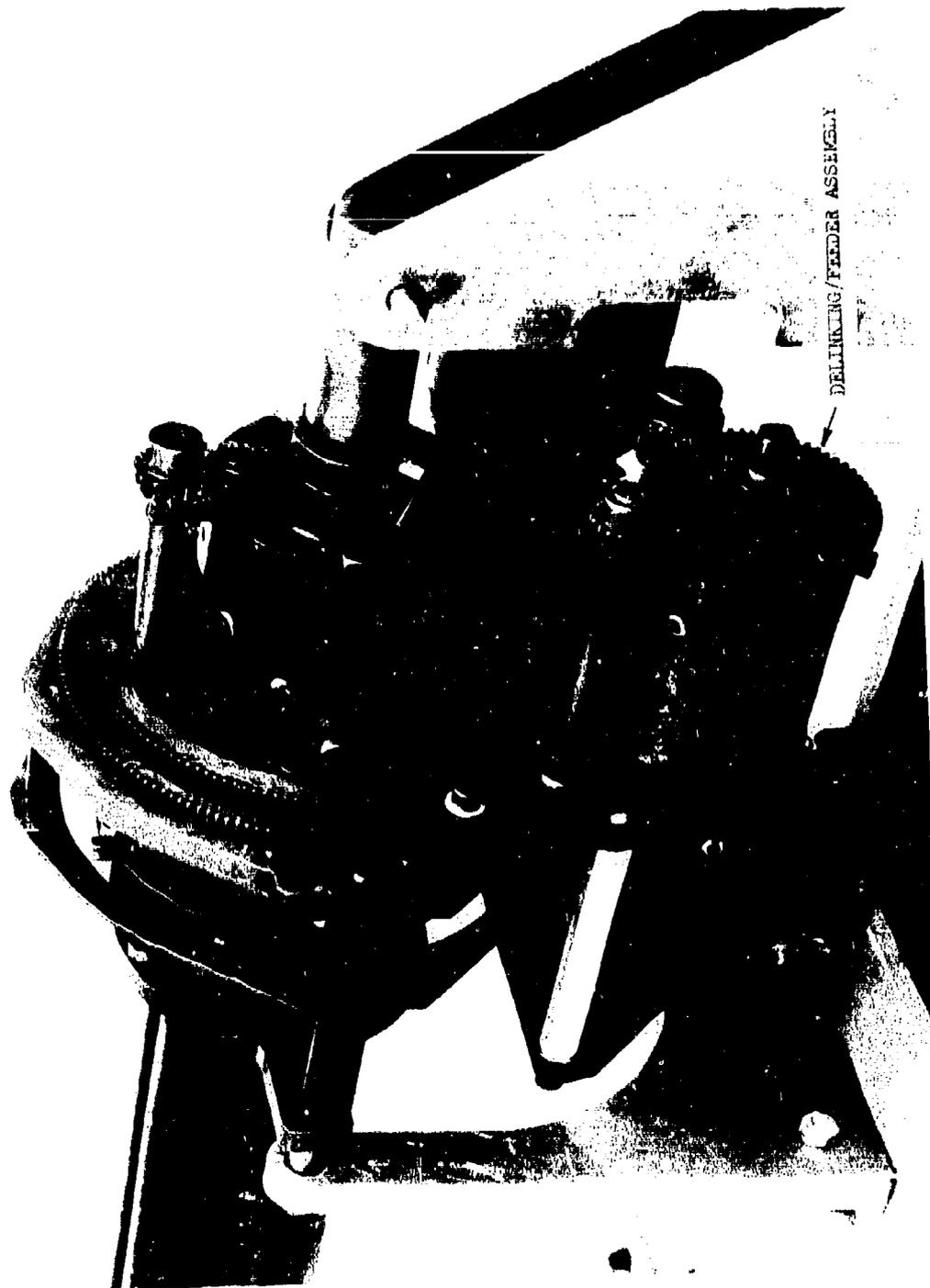


Figure II-2. Delinker/Feeder Assembly Mounted to Gun

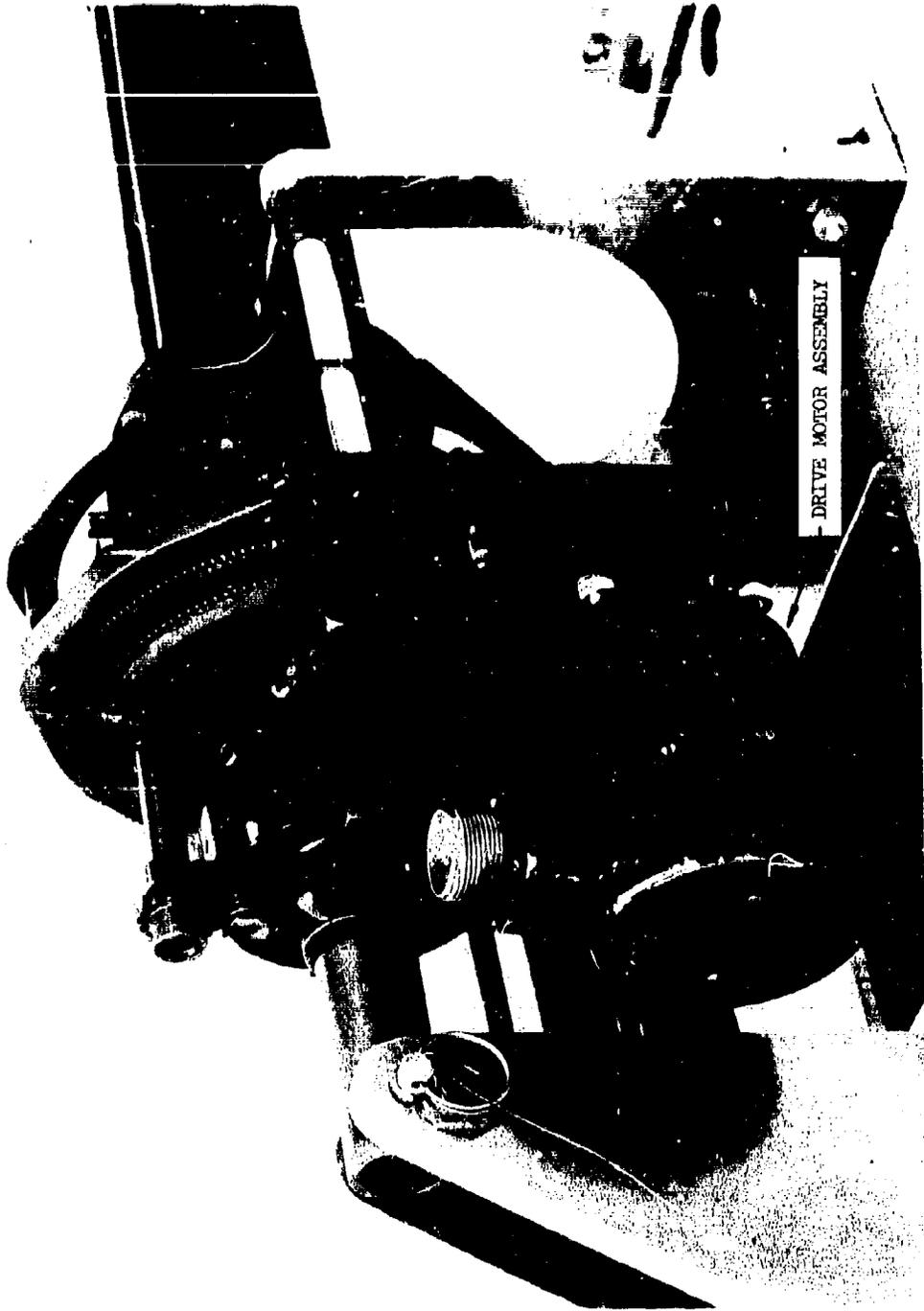


Figure II-3. Drive Motor Assembly Mounted to Gun

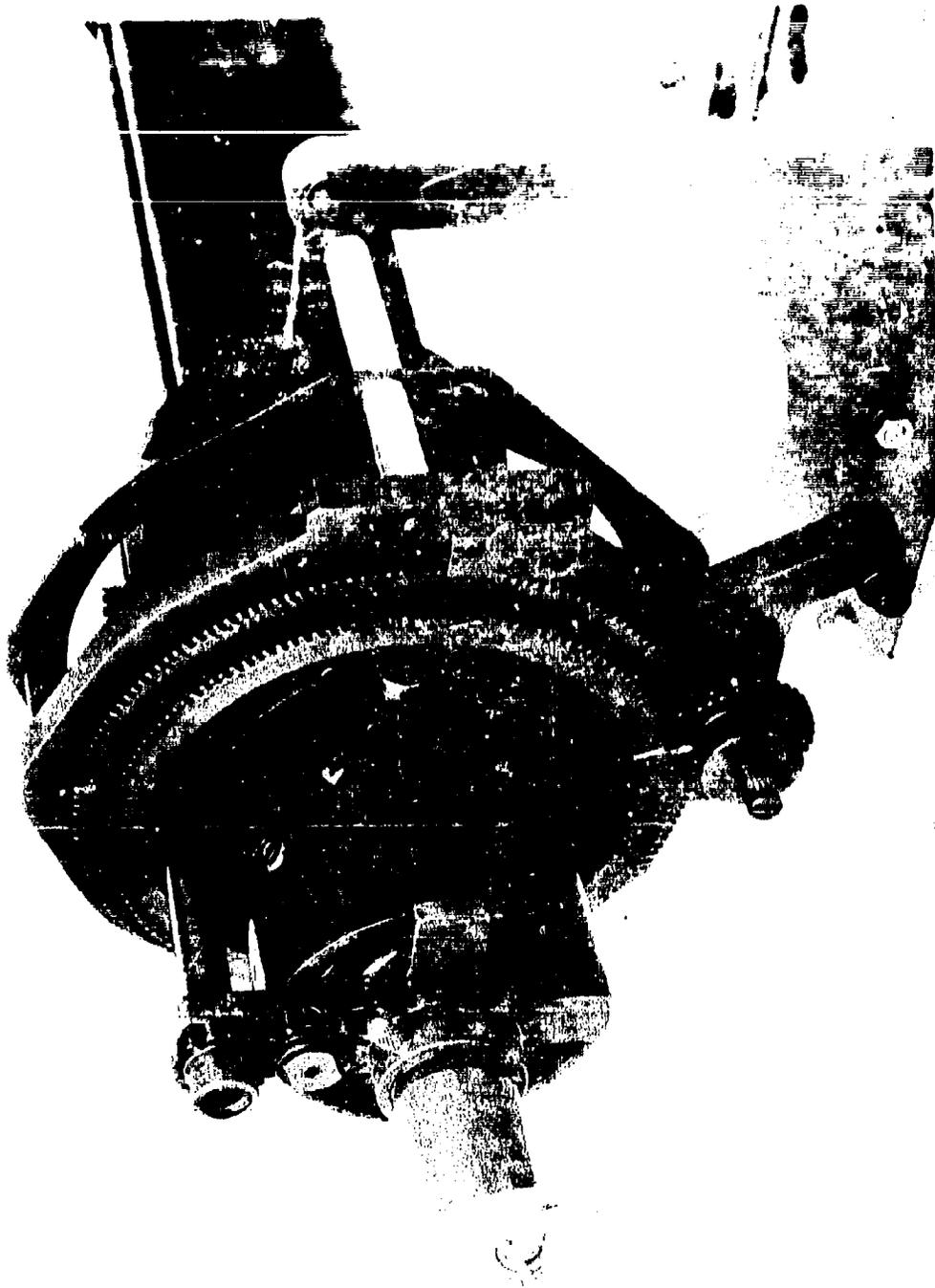


Figure II-4. Gun with Delinker/Feeder and Drive Motor Assemblies Removed

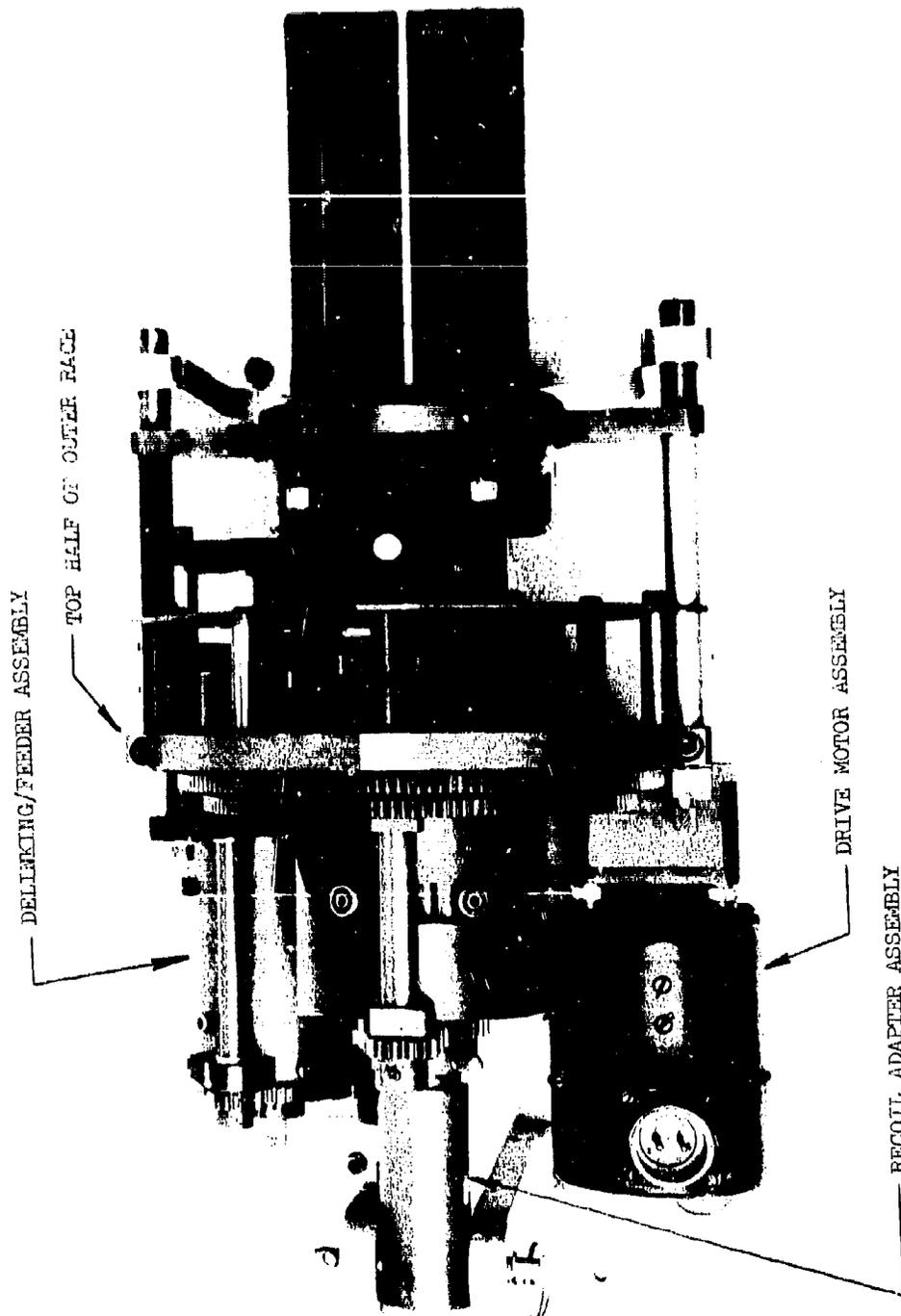


Figure II-5. Top View of Nonrotating Gun

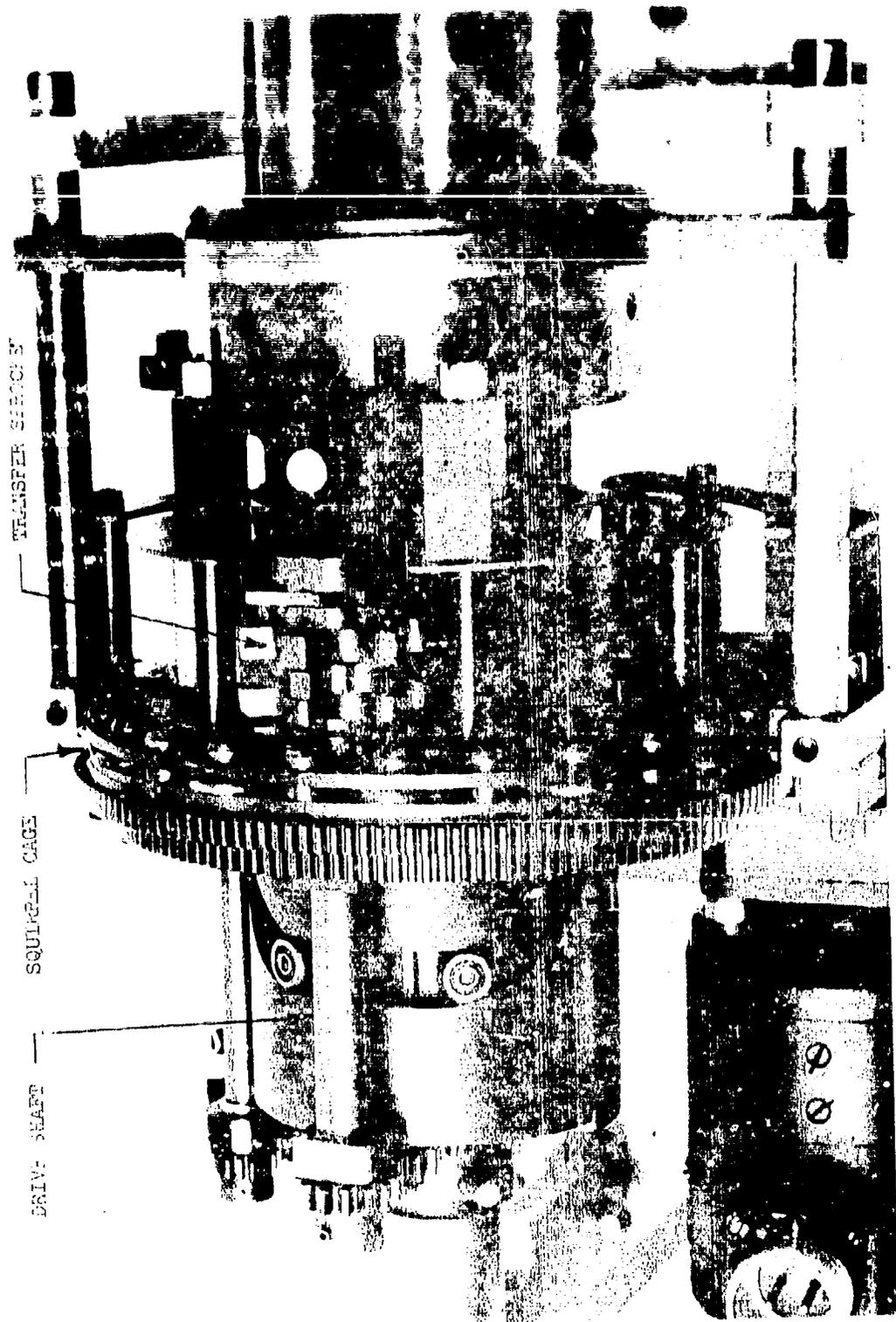


Figure II-6. Top Half of Outer Race Removed to Show Squirrel Cage and Transfer Shaft.

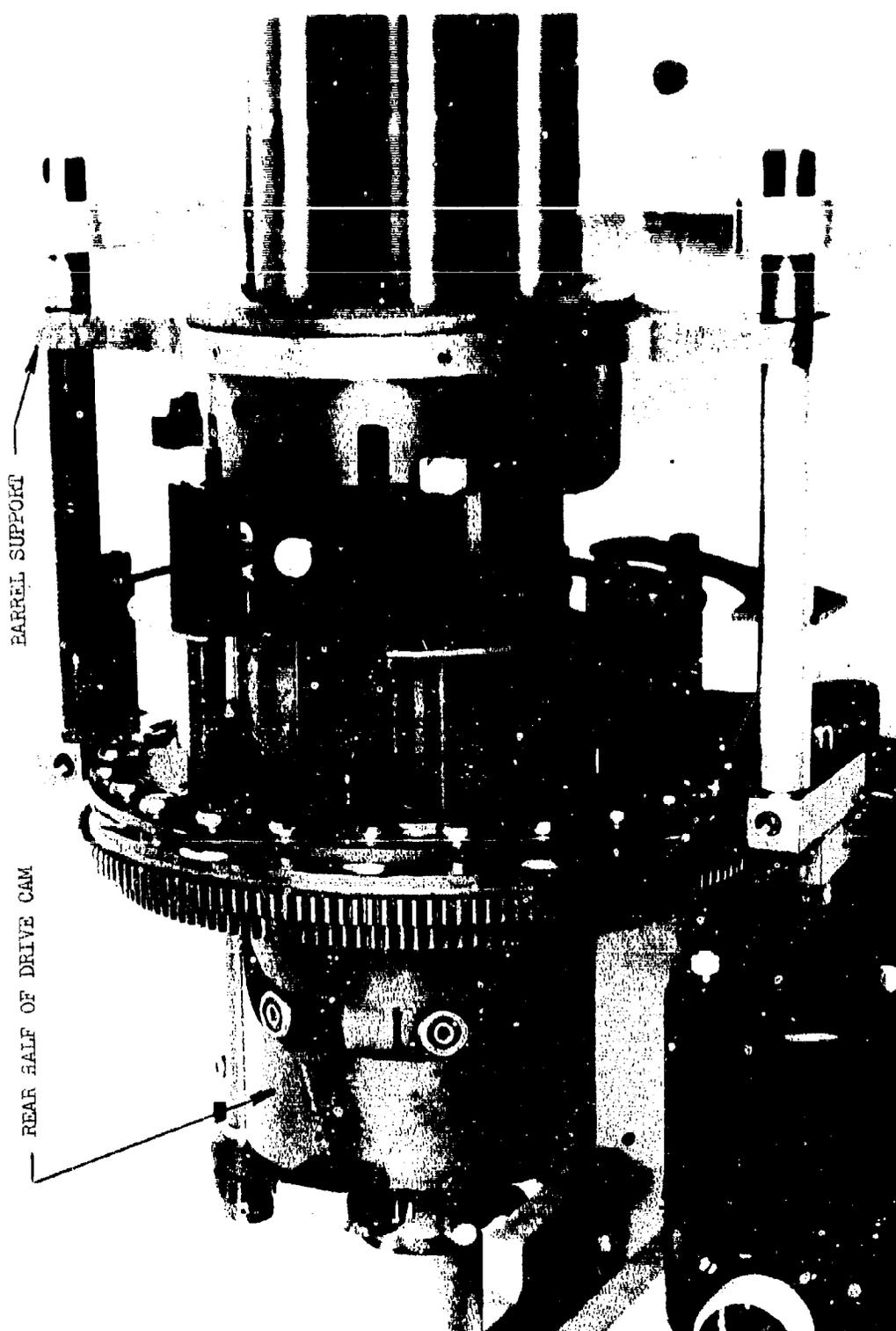
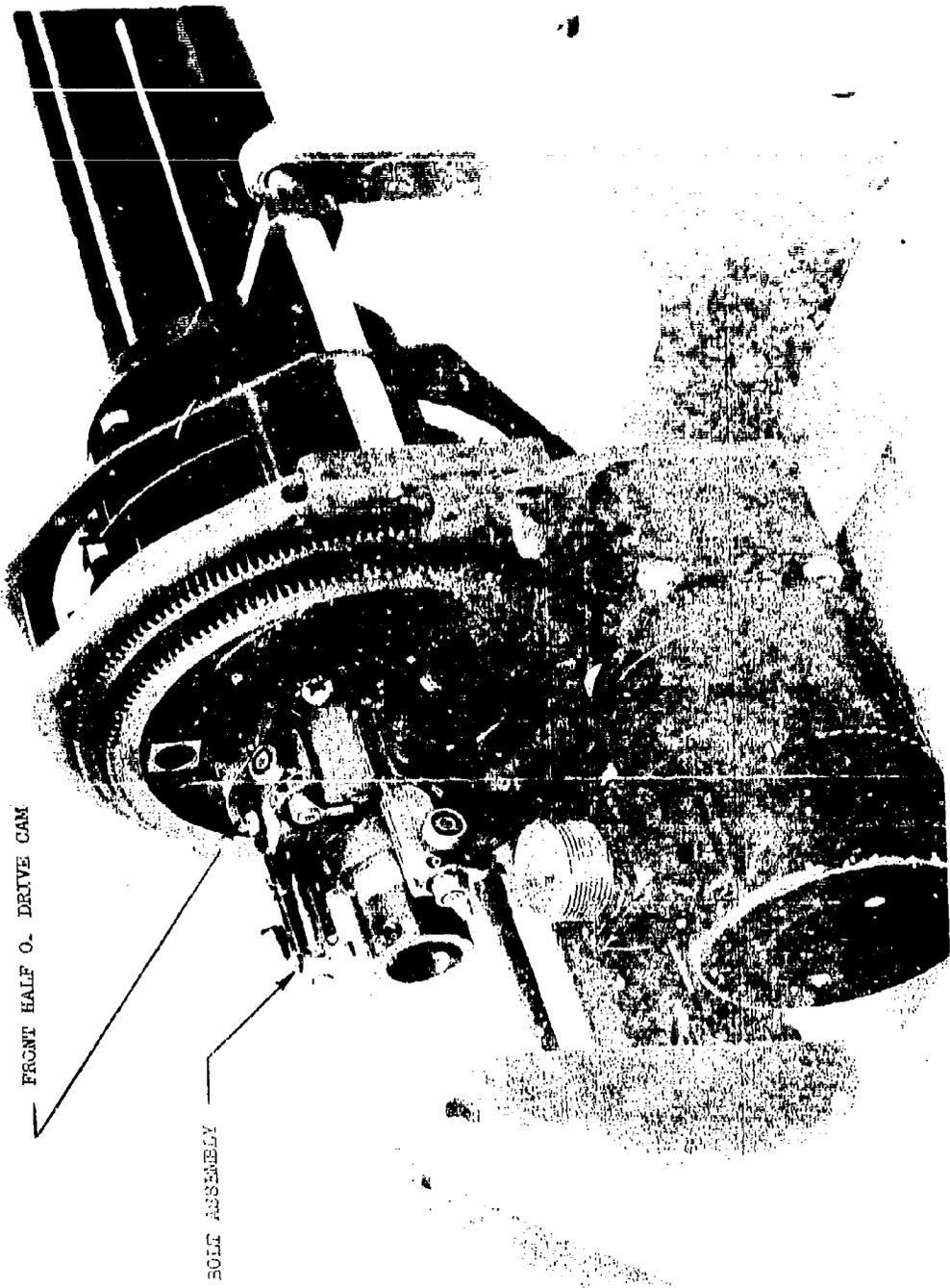


Figure II-7. Transfer Sprocket, Round Guides, and Drive Shaft Removed to Show Interior of Bar.



FRONT HALF O. DRIVE CAM

BOLT ASSEMBLY

Figure II-8. Recoil Adapter and Rear Half of Drive Cam Removed for Access to Bolt Assembly

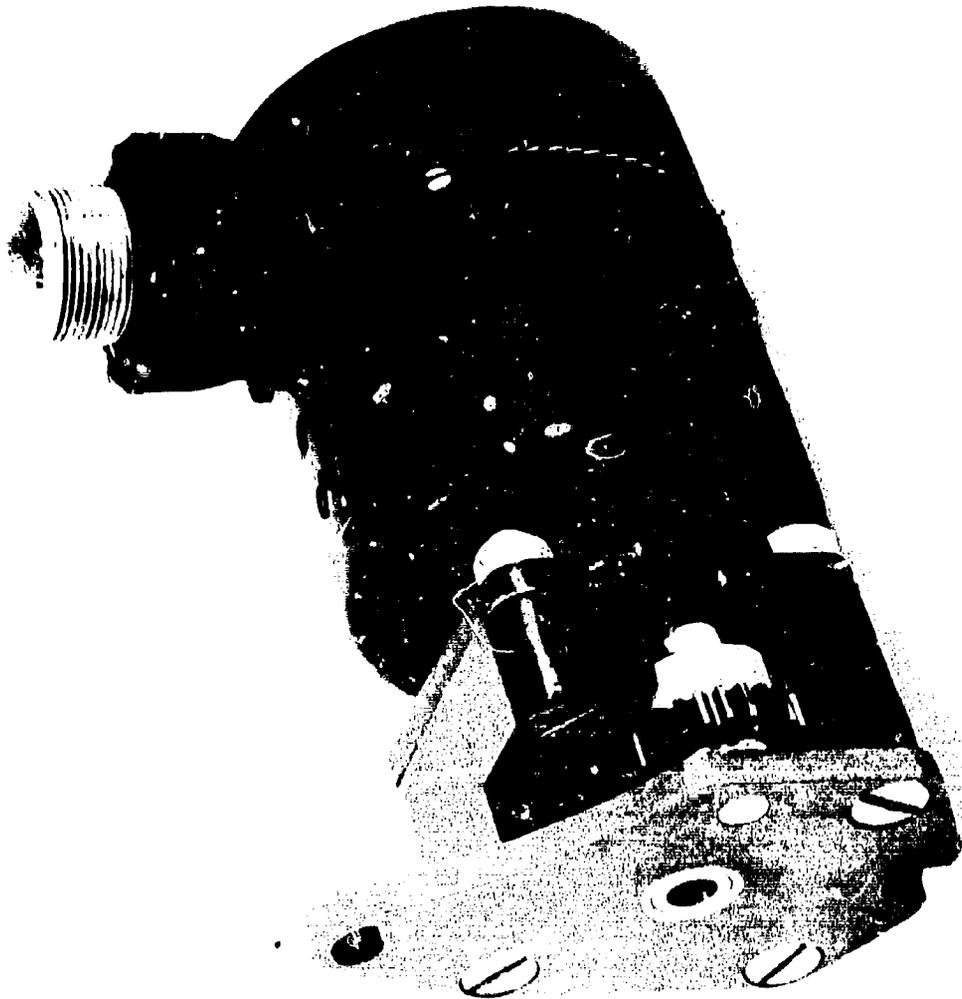


Figure II-9. Drive Motor Assembly

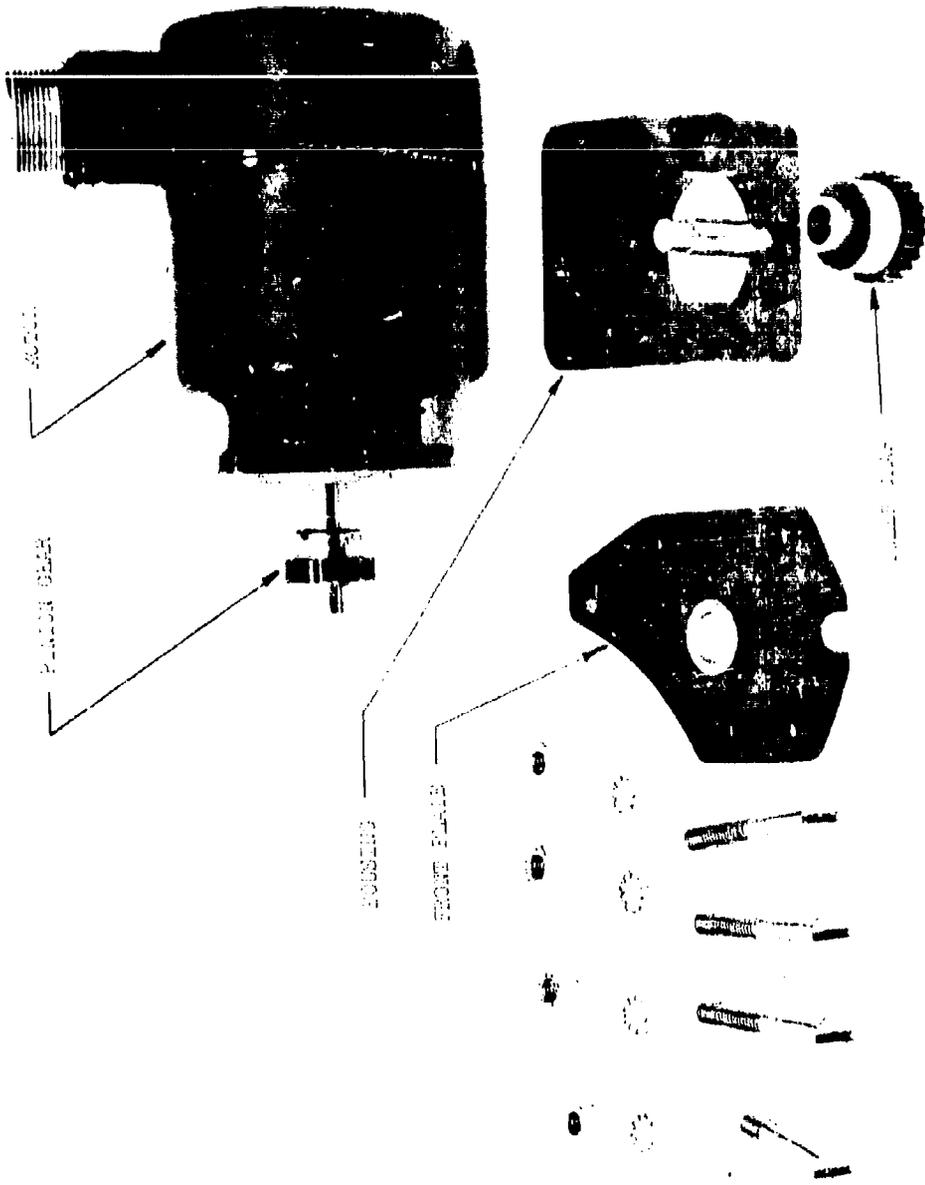


Figure II-10. Drive Motor Components

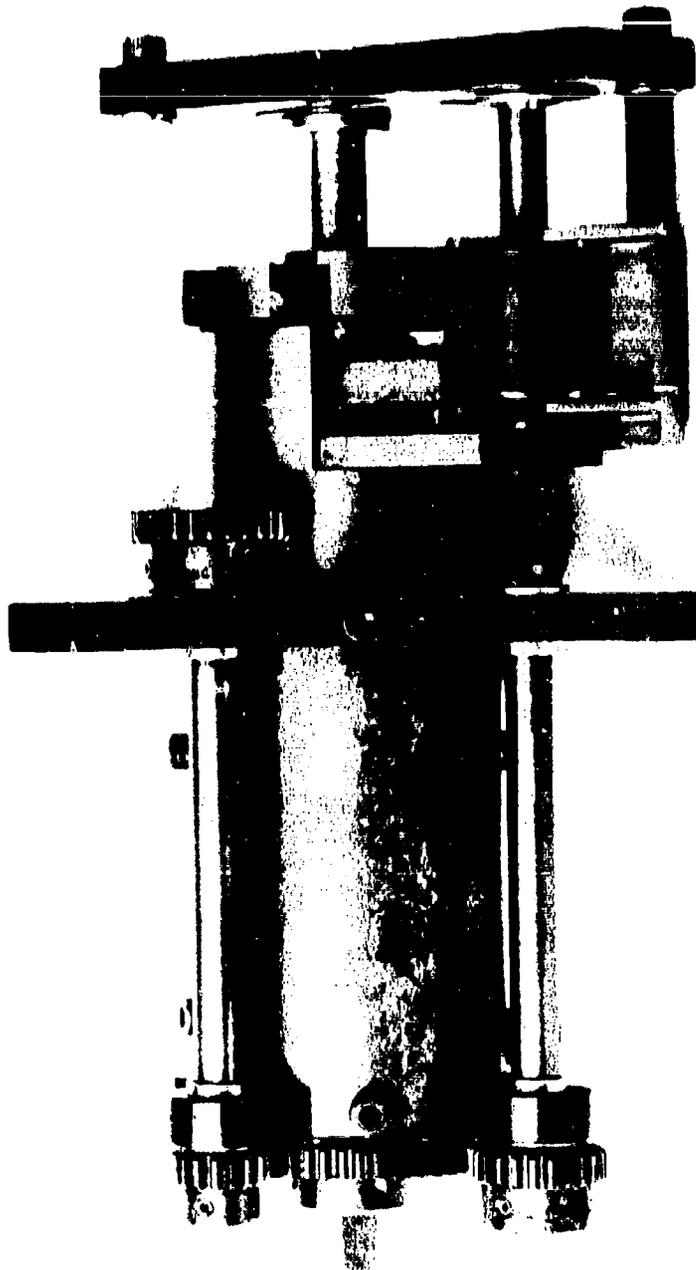


Figure II-11. Delinker/Feeder Assembly

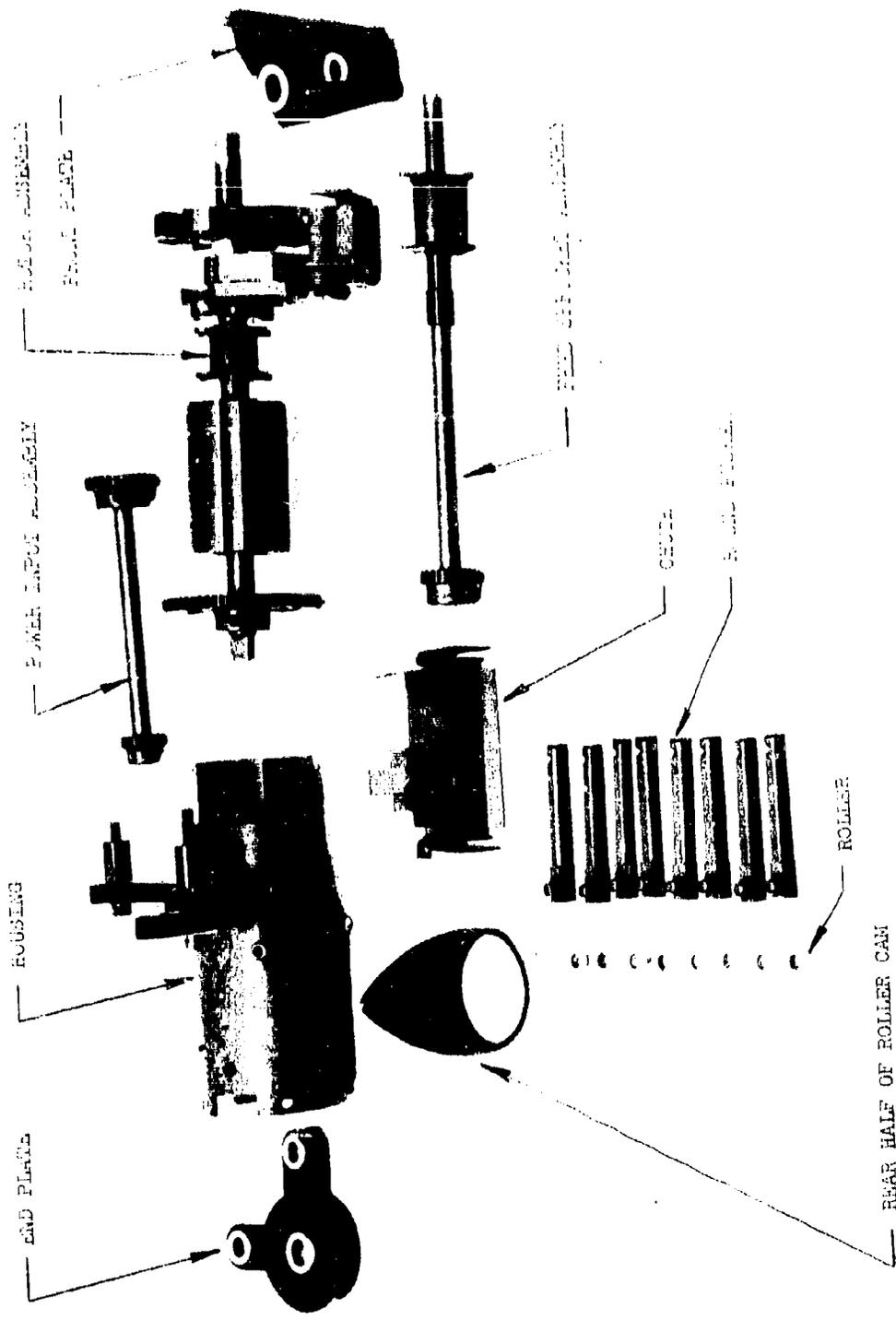


Figure II-12. Delinker/Feeder Components

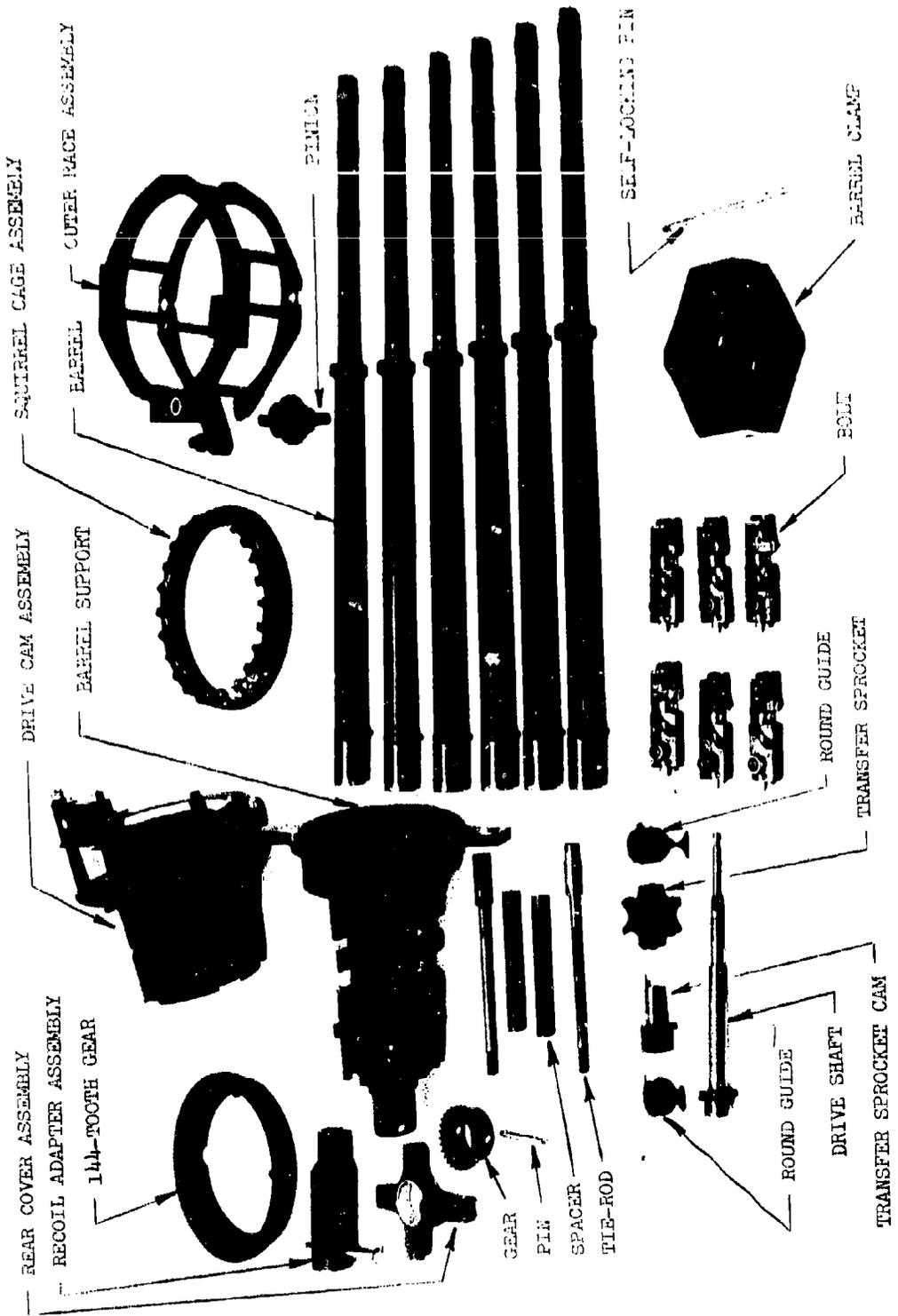


Figure II-13. Gun Components

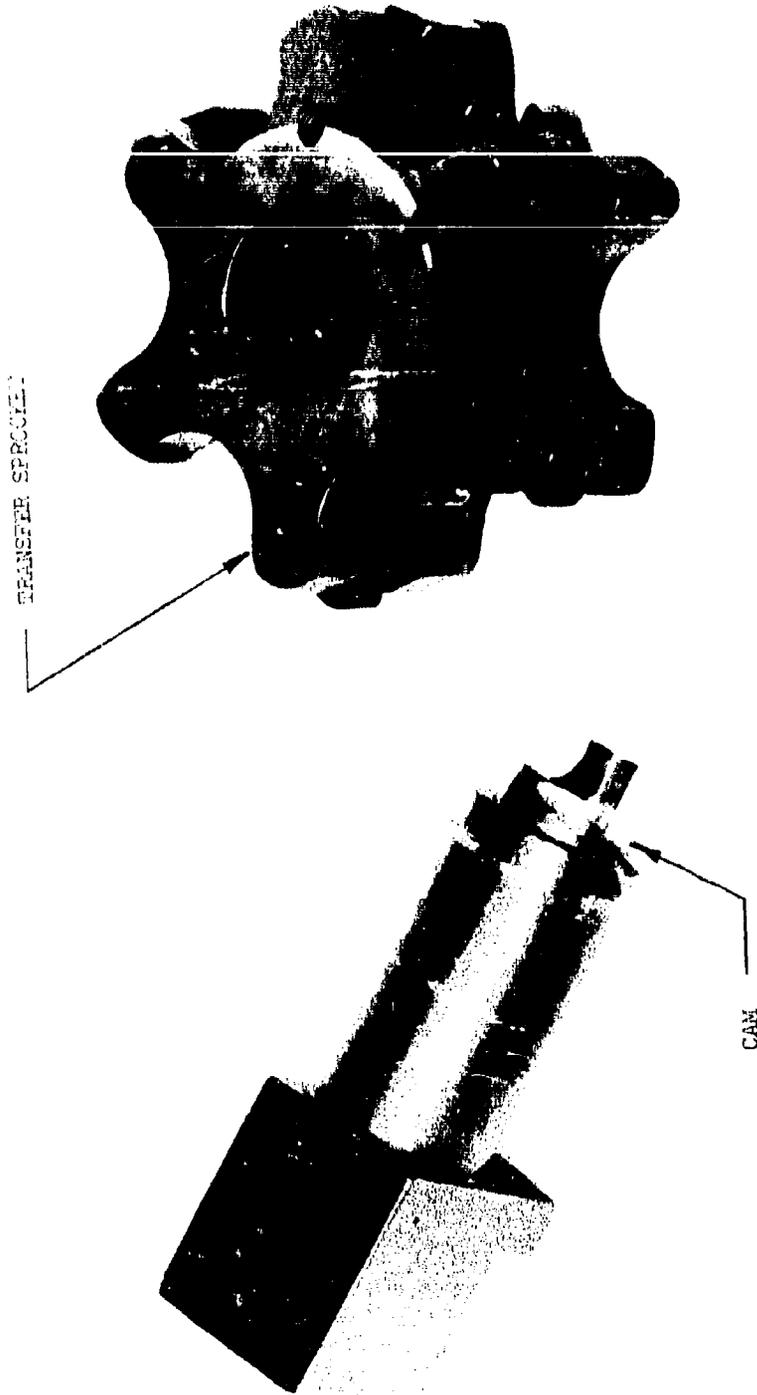


Figure II-14. Transfer Sprocket and Cam.

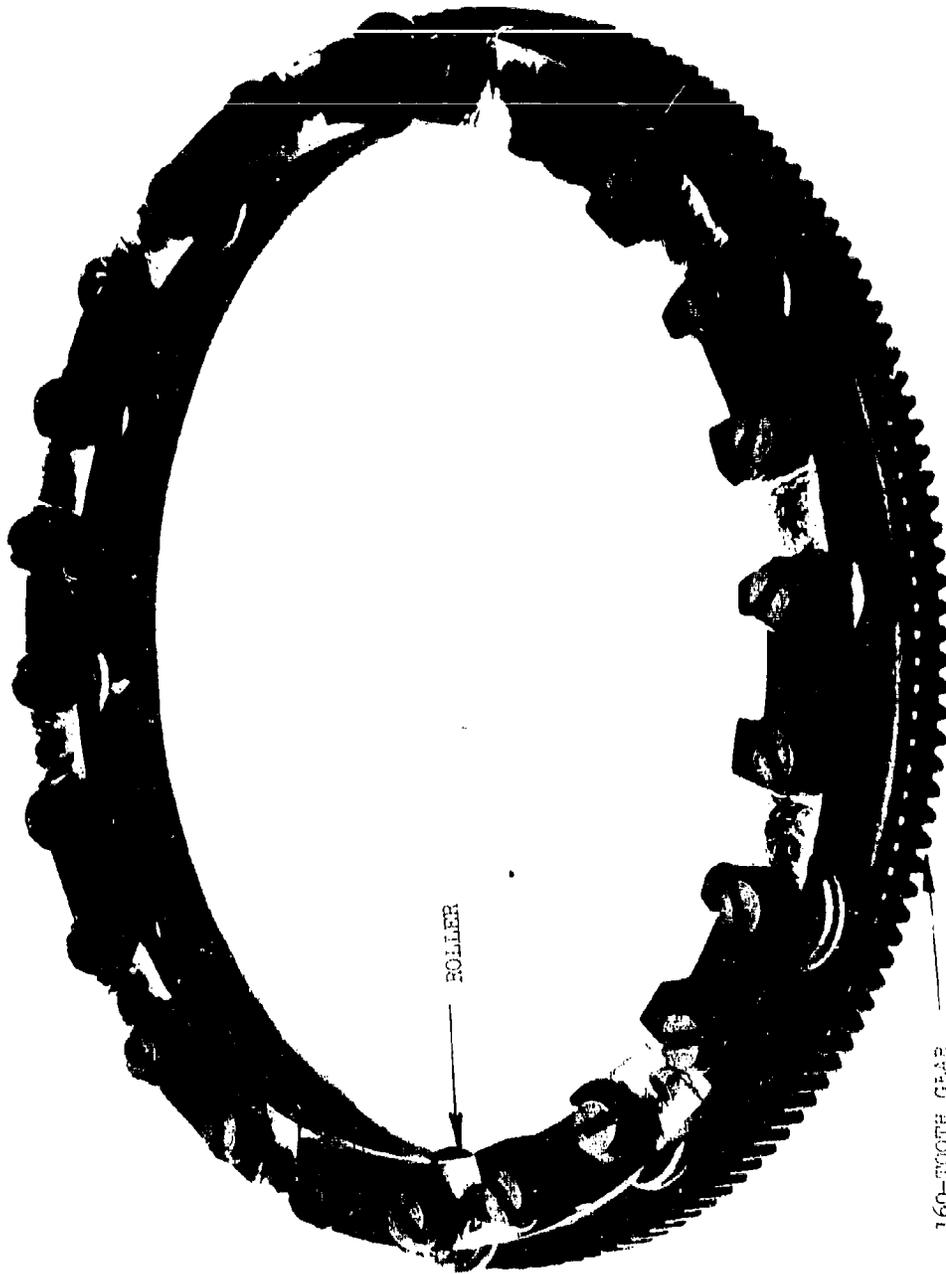


Figure II-15. Squirrel Cage Assembly

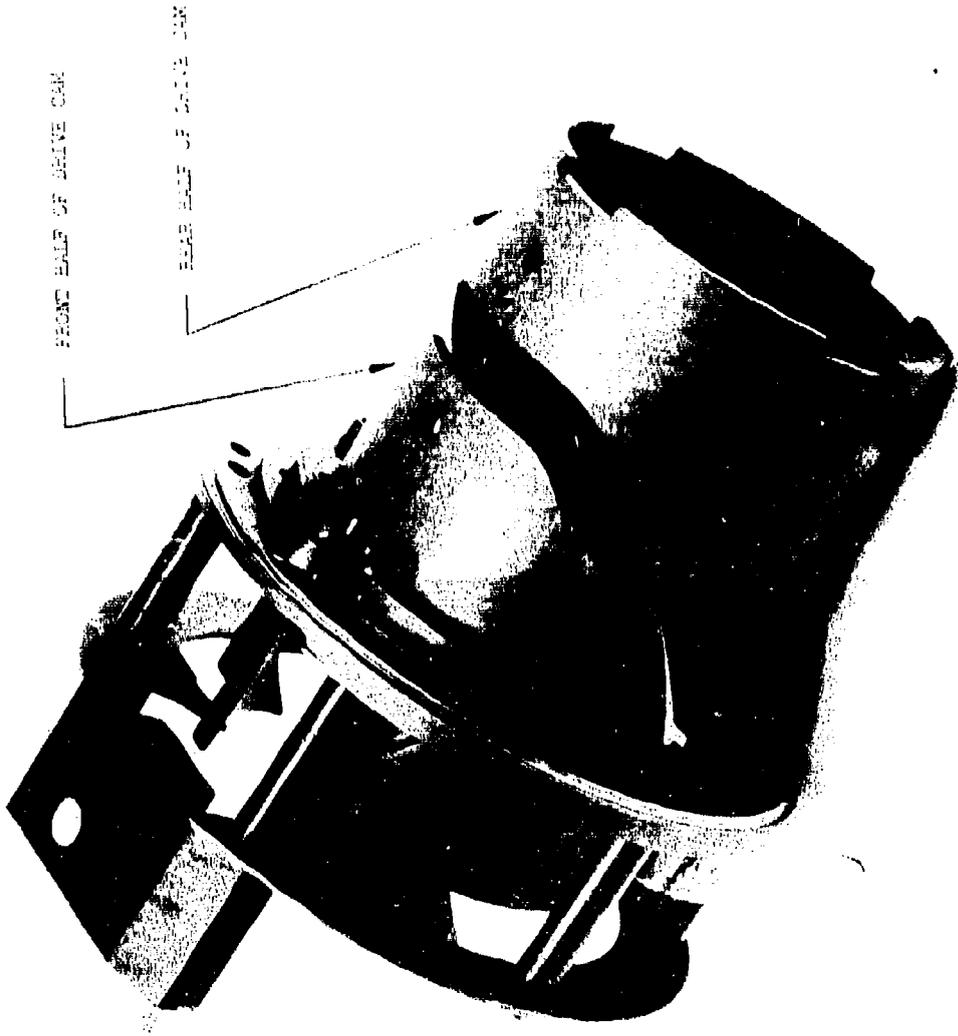


Figure II-16. Drive Cam Assembly

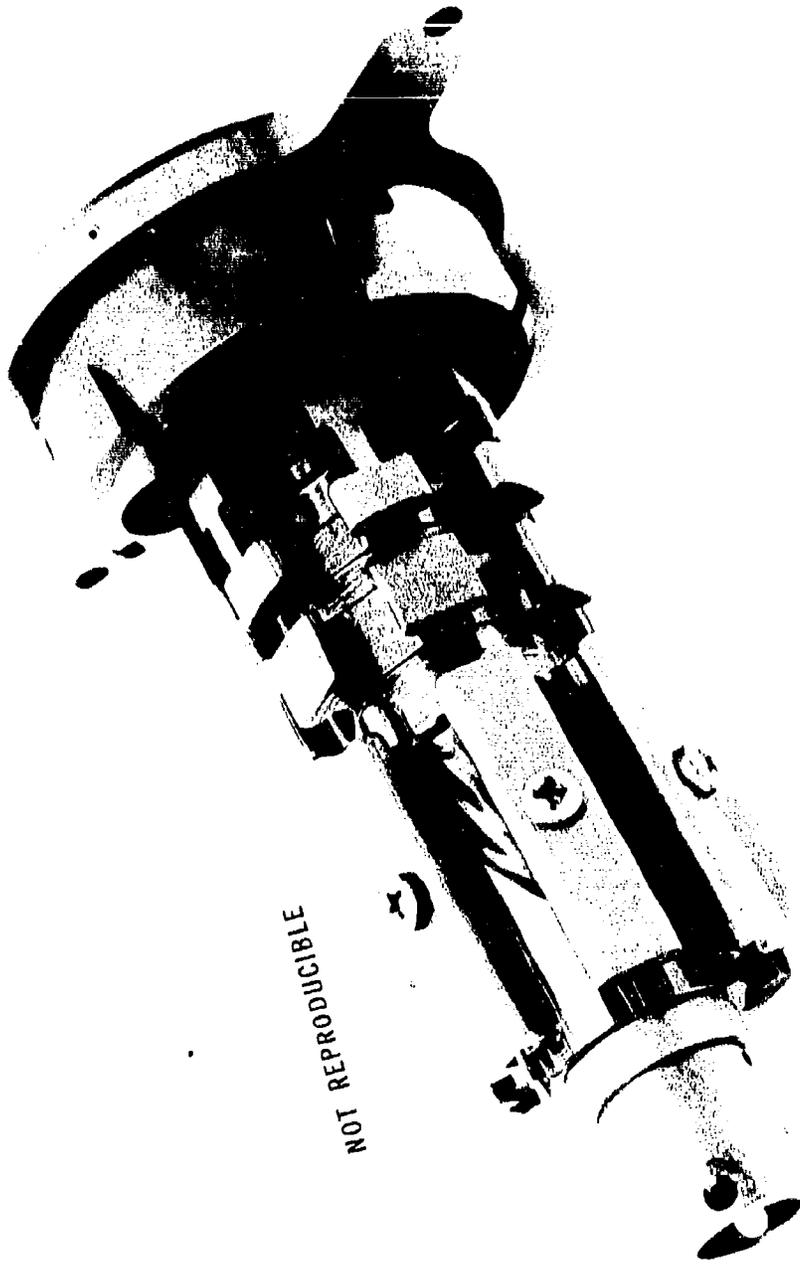


Figure II-17. Barrel Support

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

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13. ABSTRACT The development of a 7.62mm gun is described together with drawings, photographs, a firing summary, and a series of diagrams to illustrate the flow of rounds. The gun features a stationary barrel cluster. Rotating around the barrel cluster is a planetary mechanism that feeds and removes ammunition from the gun. The planetary mechanism is supplied by a continuous flow delinker/feeder that accepts linked ammunition. The gun was designed to use standard 7.62mm mini-gun barrels, bolt assemblies, bolt guideways, and a gun rotor which is altered for this application. A 24-volt DC electric motor is used to drive the weapon system.			

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Ordnance Guns Gatling gun Multiple-barrel gun Mbl gun GAU-2/A gun 7.62mm gun Externally powered gun Nonrotating gun						