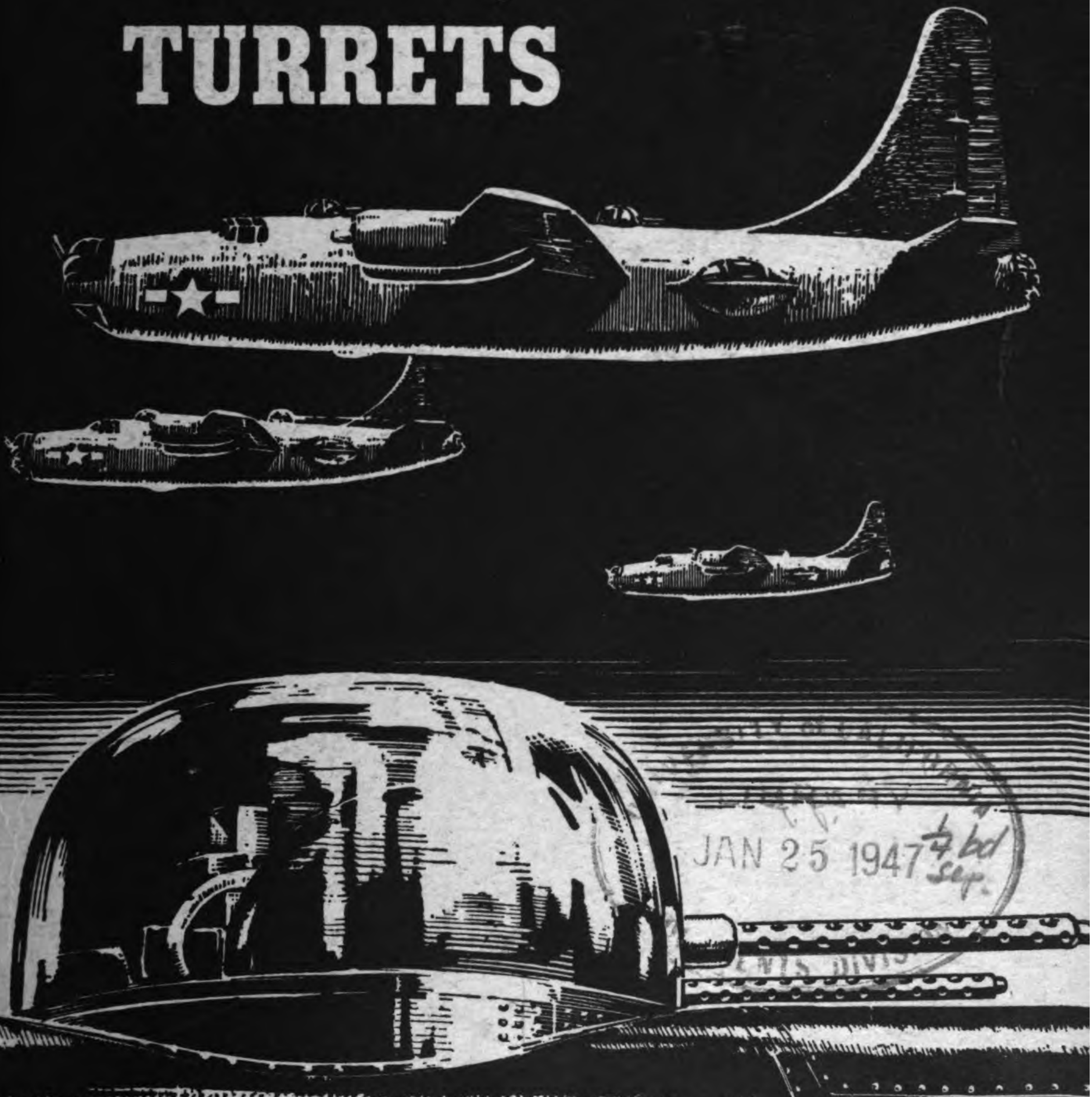
Aircraft TURRETS



1946 EDITION

NAVY TRAINING COURSES

AIRCRAFT TURRETS

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PREFACE

This book is written for the enlisted men of Naval Aviation. It is one of a series of books designed to give them the necessary information to perform their aviation duties.

A knowledge of aircraft turrets is important to all Aviation Ordnancemen and particularly to the AOMT ratings who are usually responsible for turret maintenance. Electric turrets are also the concern of Aviation Electrician's Mates and Aviation Machinist's Mates (H) are often required to maintain hydraulic turrets. Aerial Gunners, whatever their rates, know that all they can learn about the turrets in which they fly will be useful to them in a very personal sense.

This subject of aircraft turrets is relatively new, for turrets are strictly a product of World War II. How and why they operate should interest anyone engaged in any phase of Naval Aviation.

Starting with a short discussion of the various types of aircraft turrets and their applications, this book proceeds to an explanation of electric turret systems. Analyses of individual hydraulic turrets follow.

Trouble shooting procedure is covered in a special chapter, and the book concludes with an explanation of turret boresighting.

As one of the NAVY TRAINING COURSES, this book represents the joint endeavor of the Naval Air Technical Training Command and the Training Courses Section of the Standards and Curriculum Division of the Bureau of Naval Personnel.

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AIRCRAFT TURRETS

CHAPTER 1

WHY TURRETS?

DEBUT AT DUNKERQUE

Aircraft turrets made their debut at Dunkerque. A Hollywood script writer could hardly dream up a more dramatic situation.

You remember the scene. The beaches were littered with destroyed and discarded British equipment. Under pounding German artillery fire and constant aerial attack, men crowded into tiny fishing boats, and pushed onto the decks of destroyers and small patrol craft.

The British army was licked — for the time being. But in the sky, the RAF was STILL FIGHTING, throwing men and planes at the Luftwaffe's air armada.

It was on the second day of the battle of Dunkerque that an RAF squadron of Boulton-Paul "Defiants" handed Air Marshal Goering's boys a tremendous surprise. These two-seat British fighter planes had seen action before. But today, SOMETHING NEW HAD BEEN ADDED. Each Boulton-Paul was equipped with a hydraulic-powered turret, mounting two .30 caliber machine guns!

Into the swarms of Messerschmitts, Focke-Wulffs, and Junkers they flew, with turrets blazing.

What happened? That's what the Nazis were asking. After that first encounter the score stood, GERMANS—0, VISITORS—37. The turret-equipped Defiants had shot down 37 enemies without losing an airplane! And they had demonstrated to the world that the aircraft turret was HERE TO STAY.

POT SHOTS AT THE ENEMY

The PRINCIPLE of the turret is not new. King Arthur and his knights used it. Centuries ago, warriors realized the strategic importance of being able to heave a spear or fire a crossbow from a fortress into some direction other than straight out the window.

In other words, they wanted to INCREASE THEIR ANGLE OF FIRE. So they added a turret tower that stuck out from the main fort. Then they could stand in the turret and take pot shots along the wall to the left, along the wall to the right, or to any point in the three-quarter circle which formed the new angle of fire.

Airplane turrets INCREASE the gunner's ANGLE OF FIRE in the same way. Also, they furnish power-controlled movement of the turret and guns against the force of the slipstream.

At the beginning of World War I, airplanes were used only for observation purposes and were not armed with machine guns. With the development and adoption of the two-seater observation plane, a single machine gun was mounted in the observer's cockpit. It was set on an upright post with a swivel on top so the gun could be swung in the desired direction.

When the speed of airplanes was increased, it was impossible for the gunner to swing the guns against the terrific PRESSURE OF THE SLIPSTREAM. So the gunner and guns were enclosed in a glass dome with the guns sticking out through slots. As the guns were still swung manually, the gunner was not much better off than before.

Then HYDRAULIC POWER was used to swing the turrets, but the guns were still elevated by the gunner. This was a great improvement, but not until power was used to elevate the guns as well as to turn the turret did the full effects of turret fire power become realized.

A WORLD WAR II BABY

While turrets of other sorts are centuries old and many of the principles and advantages of using turrets are equally ancient, the AIRCRAFT turret is PRACTICALLY A BABY. It's strictly a product of World War II.

After Dunkerque, the British installed Boulton-Paul turrets in a BOMBER, the "Wellington," made by Vickers-Armstrong. Some of these turrets were sent to America for instruction purposes. But turrets of American design were already on drawing boards, and soon after that, in production.

From HYDRAULIC to ELECTRIC-POWERED turrets was a short step, and turrets of each type were available by 1942 in several different designs.

Eventually, remote-control turrets were produced for aircraft. These have been used in action by a number of nations. At the present time, however, the Navy has no airplane incorporating this type.

The efficiency of turrets and their general usefulness have increased tremendously since they were first put into service. Firepower has increased, too, so that turrets, through their guns, deliver a much bigger KICK than did the early models.

The old Boulton-Paul had a pair of .30 caliber machine guns. Turrets soon came out with one .50 caliber BAM. Now most turrets have two .50's, and some have been used mounting two 20 MM aircraft cannon.

Like airplanes, turrets are designed for SPECIAL JOBS. Some are "upper deck" turrets, mounted on the topside of the fuselage. Others are located in the nose, belly, sides, and tail — depending, of course, on the type and purpose of the aircraft.

Turrets help furnish protection for the gunner, but they are placed on aircraft for ONE PURPOSE — to help the gunner shoot better! And as you know, the gunner is not along just because the pilot wants company. His job is to SHOOT DOWN ENEMY AIRCRAFT.

Any number of examples can be given of the importance of the gunners, their guns, AND their turrets to any bombing mission. In fact, there are just about as many examples as there are successful missions involving enemy action.

Here is a quotation from a pilot's story describing an attack on a Jap airfield —

"I went down, and we dropped the bombs. Just as I began climbing out, a fighter jumped me. Right behind him was another fighter. Each time they made a run, I tried to give them the poorest possible shot. Believe me, I was plenty scared and kicking that plane around. But my gunner was busy, too. He really saved us, because he got one of those fighters. I nearly cheered when I saw it go down. Then he got the other fighter smoking, and I could have kissed that boy. We got back to the ship without any further trouble."

This TBF pilot's story is so typical and so common that it could fit into almost any similar combat report. When you read of PB4Y's, PBM's, TBF's, or PV's going into action, you know that others beside the pilots are plenty busy and plenty IMPORTANT. Those others include the gunners. And how those gunners perform depends to a large extent on HOW THEIR TURRETS PERFORM.

Just exactly what does a modern turret consist of?

TURRETS TODAY

The turret, as you know it today, is a self-contained, mechanized unit, consisting of an enclosure housing the gunner, guns, armor plate, driving units, and all accessories. The Navy uses quite a few different makes of turrets on its aircraft, and each has its own code designation which describes its distinguishing features.

Have a look at this partial list of Navy turrets.

MPC 250 CH–6B	Tail of PB4Y–2
ERCO 250 TH–1A	Right Waist, PB4Y–2
ERCO 250 TH-2A	Left Waist, PB4Y–2
Martin 250 CE–16A & 17A	Upper PB4Y–2
Emerson 250 SE–10	Bow PB4Y–2
Martin 250 SH–2	Bow PB2Y–3, –4

Martin 250 SH–3A	Bow of PBM–5
Martin 250 CH–1B	Upper Deck PBM–5
Martin 250 CH–2B	Tail PBM–5
Grumman 150 SE–2	Upper TBF–1
Martin 250 CE–13	Upper PV–2

You can identify Navy turrets easily if you know how to read the code designations.

Take a Grumman 150 SE–2 turret, which is installed on a TBF–1. First the name "Grumman" means that the turret is designed by the Grumman Aircraft Corporation. The number "150" means that the turret is armed with one .50 caliber machine gun. The first letter of the code "SE" tells you that the turret is spherical (ball) in shape. The "E" informs you that it is electrically operated. The number "2" at the end is merely a modification number. An additional letter, usually "A" or "B," denotes a further slight modification.

The following diagrams will give you a still better idea of how to read the code designations of different Navy turrets.

Designer
Number of guns
Caliber of guns
Spherical in shape
Electrically powered
Modification number
Grumman 150SE–2

Designer
Number of guns
Caliber of guns
Cylindrical in shape
Hydraulically powered
Modification number
Martin 250CH–2

Designer
Number of guns
Caliber of guns
Teardrop in shape
Hydraulically powered
Modification number
Erco 250TH–2

All the turrets the Navy uses can be broken down into three mechanical classifications and two power-operating mechanism classifications.

Mechanically, turrets are classified according to their shape. First, there is the ball or spherical type on which the gunner, guns, and sight rotate about a common axis in ELEVATION and

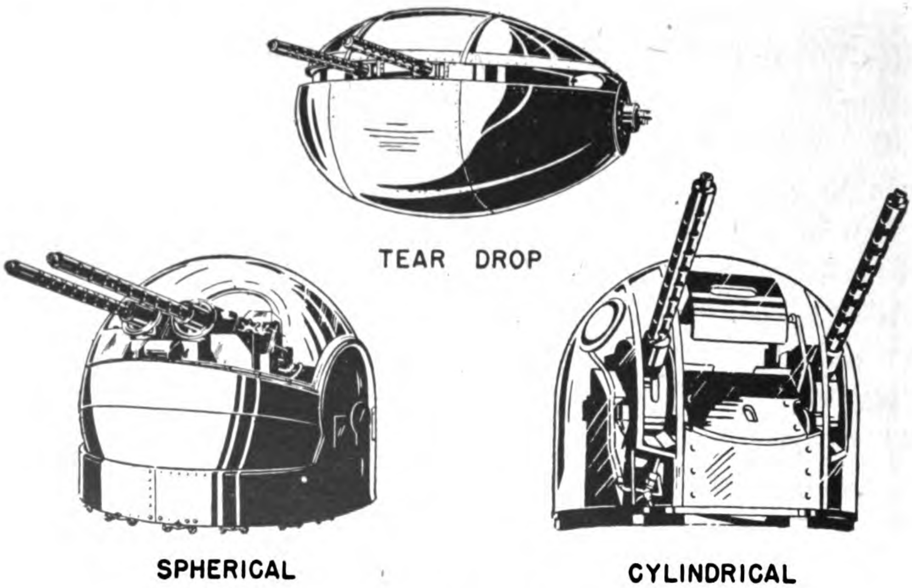

Figure 1.—Turret shapes.

a common axis in AZIMUTH (horizontal). The second type is the cylindrical turret in which the gunner, the guns, and the sight rotate about a common axis in AZIMUTH while only the guns and sight operate in ELEVATION. The third, a teardrop turret, is one which is essentially a streamlined shape with one axis of rotation along the chord of the streamlined shape. Gunner, sight, and guns all move together both in AZIMUTH and ELEVATION.

CHAPTER 2

ELECTRIC TURRET SYSTEMS

ELECTRICITY, THE DRIVING FORCE

When a bolt of lightning blackens a tree — that's ELECTRICITY at work. Your girl combs her hair and little blue sparks crinkle through it. ELECTRICITY is working again.

And when a Grumman turret whirls around and gives an aerial gunner a nice bead on an enemy fighter, THAT'S electricity at work, too!

What is electricity? If you can answer that one, go to the head of the class. ANY class.

The fact of the matter is, no one really knows just exactly WHAT electricity is. But don't let that worry you. How to define electricity is a subject for the long-haired boys to argue about. What electricity DOES and how it ACTS are what should interest you in your study of electrical turret systems.

This book is not designed to give you a course in basic or advanced electricity. Don't get the idea that you have to be an electrical engineer to understand electric turrets. That certainly isn't true. But an understanding of electrical principles — the commonest ones — will help you a lot. What you will be dealing with primarily are electrical circuits — the flow of electrical current through a closed channel, starting at one point and returning to that point.

Ask an electrician a question, and he'll probably answer you by whipping out a pencil and drawing a quick sketch or diagram. In telling a technical story, diagrams are usually worth

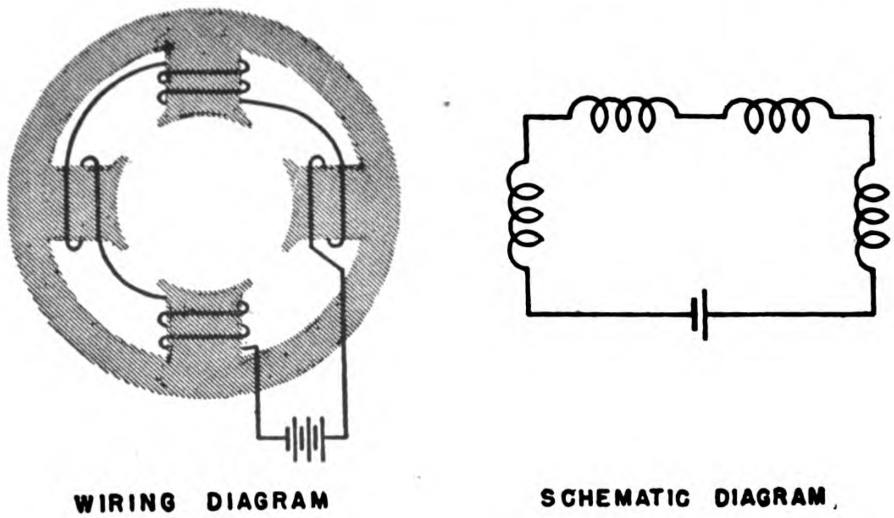

Figure 2.—Types of diagrams.

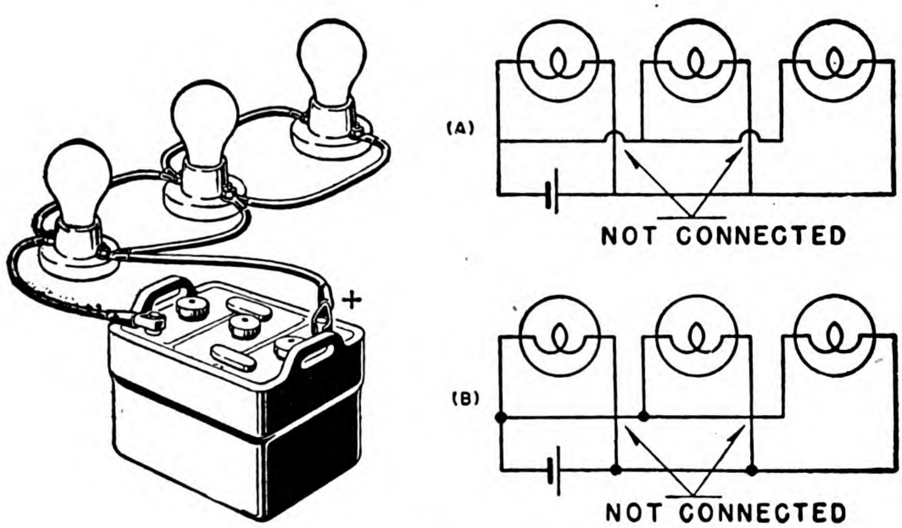

Figure 3.—Wire connections.

a good many thousand words. They get the POINT over fast and eliminate confusion.

Therefore, before going any farther with turret electrical systems, here's a short explanation of two types of diagrams commonly used to explain electrical installations.

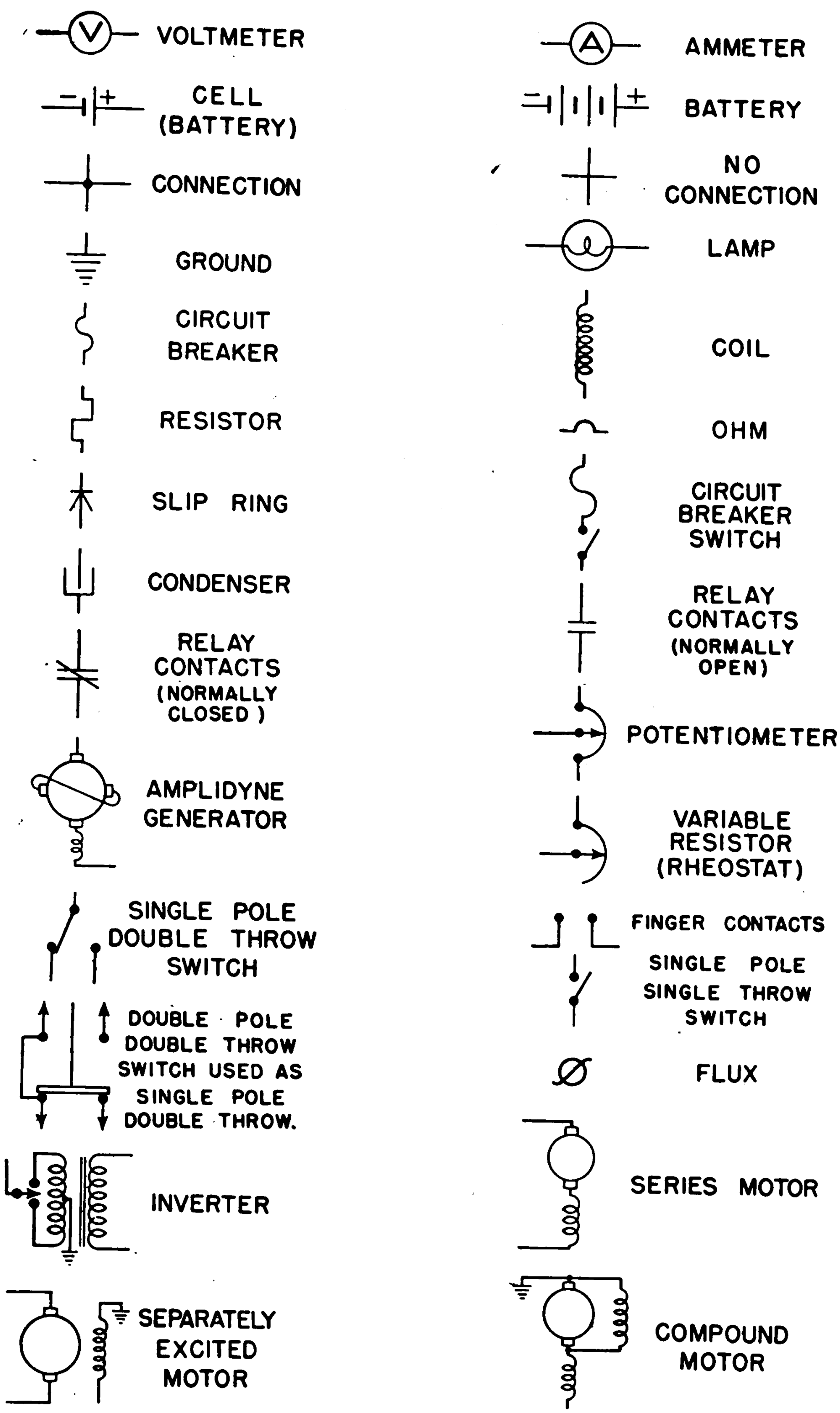

Figure 4.—Electrical symbols.

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Certain structural parts of a circuit, as well as connection wires, are shown in a WIRING DIAGRAM. In a SCHEMATIC DIAGRAM, electrical parts are represented by symbols and only the scheme of the connection is indicated. The two diagrams in figure 2 show exactly the same thing. Both illustrate the connection pattern of coils in an electric motor. Note that the schematic diagram uses a form of shorthand.

In figure 3, you have three lamps connected to a storage battery. Note the TWO common methods of representing wire connections in schematic diagrams.

By the method in *A*, you use a **U**, or loop, to show a crossing of two wires that are not connected, and you show a connection by a crossing at right angles.

By the method in *B*, a crossing point of two wires is a connection ONLY if you place a DOT there.

Figure 4 shows widely used electrical symbols. You'll need to understand these and recognize them in order to read electrical shorthand.

MEET THE POTENTIOMETER

You'll be getting well acquainted with an instrument known as the potentiometer in your dealings with electric turrets.

What does it do? The potentiometer regulates ELECTROMOTIVE FORCE (emf or voltage). And that's what makes an electric turret TICK.

Figure 5 shows how the potentiometer ties in with the control unit.

The potentiometer is really like a rheostat. You know how the volume control rheostat works on your radio. Turn it one way, and it swells the volume up. Turn it the other, and it cuts it down.

Think of the potentiometer as a VOLTAGE DIVIDER. Like the volume control on your radio, it "marks off" the flow of electromotive force so it does what you want it to do.

Turrets move in two planes. One is horizontal, and movement in this direction is called in TRAIN or AZIMUTH. Up-and-down movement is referred to as ELEVATION and DEPRESSION.

The potentiometers (there are two of them) work through the control handle and control the movement of the turret either in TRAIN or ELEVATION.

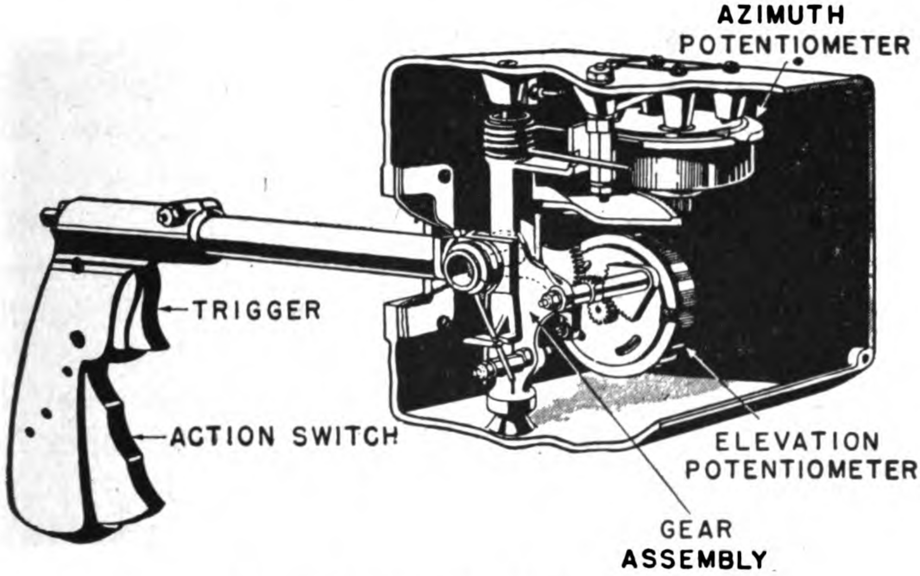


Figure 5.—Control unit (cutaway).

When you move the control handle up, it deflects the pointer on the potentiometer. Then the turret points down — that is, it depresses.

You'll note the two potentiometers as they appear in figure 5.

In figure 6 you'll see a simple circuit consisting of a battery

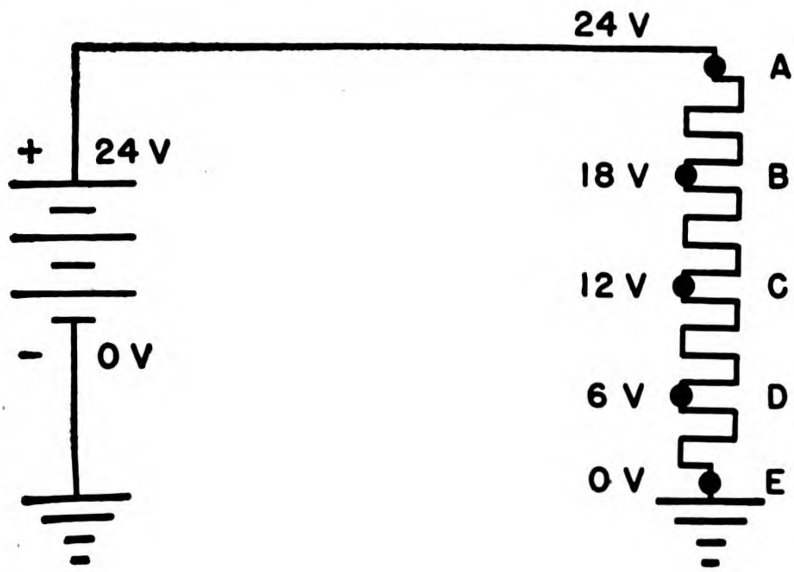


Figure 6.—Battery and resistor.

and a resistor. At the top of the resistor there exists a potential of 24 volts with respect to the negative side of the battery or ground. To check this, a voltmeter across points *A* and *E* will give a reading of 24 v., since a voltmeter measures the DIFFERENCE IN POTENTIAL between two points in the same electric circuit.

EFFECTIVE VOLTAGE

Now take a look at midpoint *C* in figure 6. Here a potential of 12 v. exists, once again with respect to ground and assuming the resistor is of uniform resistance throughout its length.

If you take a voltmeter (which, of course, is a device for measuring voltage) and check between point *C* and point *E*, you will get a reading of 12. This is the DIFFERENCE IN POTENTIAL between these two points.

Likewise, at midpoint *C*, there is an EFFECTIVE VOLTAGE of only 6 v. with respect to point *D*. You can check this by plac-

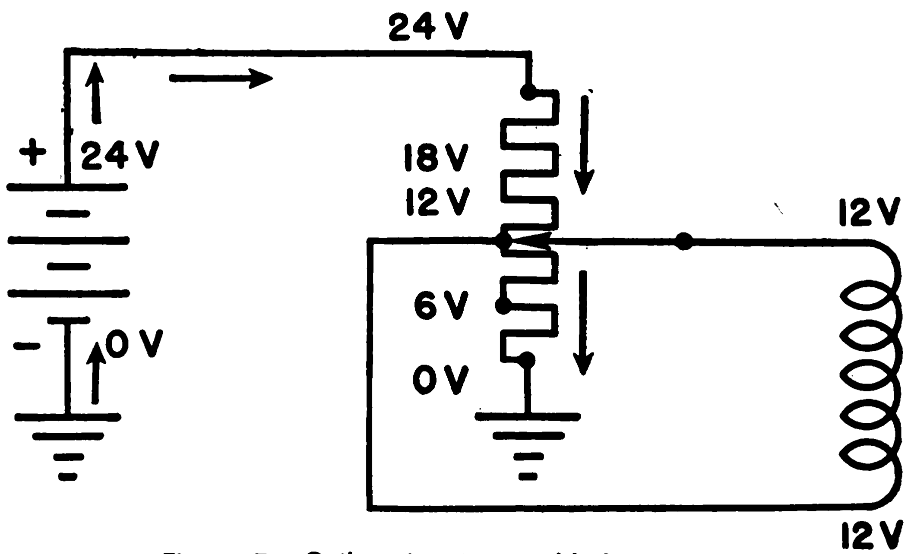


Figure 7.—Coil and pointer added to circuit.

ing your voltmeter between points *C* and *D*. The difference in potential between these two points will be 12 v. minus 6 v., or 6 v.

As you can see, that voltage existing at any particular point is WITH RESPECT to the voltage of some other point in the circuit.

Now take a look at figure 7. Something new has been added.

To be specific, a COIL and a MOVABLE POINTER. The current path is indicated by the arrows (from battery through resistor to ground and then through ground back to battery).

Right here you should know that the voltage on an aircraft electrical system is 24–28 v. Usually, it is computed to be 27.5 v. But for simplicity, in all the electrical examples in this book, it is assumed that you are working with a constant of 24 v. So remember that the figures given in the examples would not necessarily check with the readings you would get in an actual aircraft electrical system. They would vary proportionately (as 27.5 is to 24).

In figure 8 the movable pointer has been moved up to the top of the resistor, allowing 24 v. to be impressed on the top side of the coil and about 12 v. to be impressed on the bottom side.

Now what have we? The "effective voltage" of about 12 v. (difference between 24 v. minus 12 v.) sends the current down

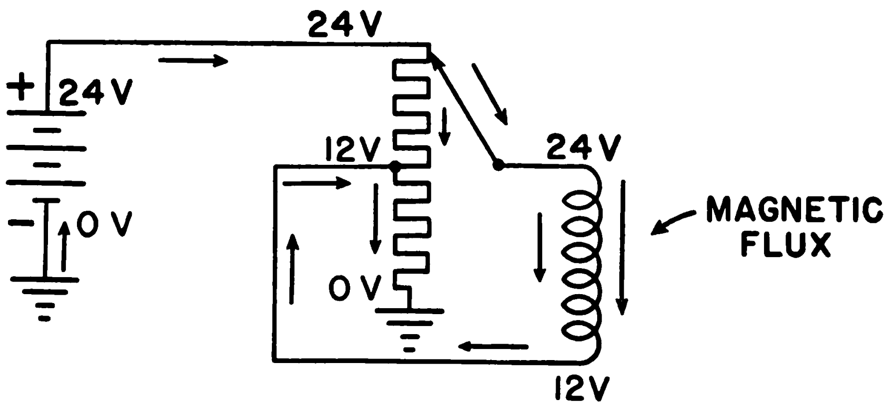


Figure 8.—Pointer moved to top of resistor.

through the coil. This current flow sets up a magnetic flux or field about the coil. To simplify things, consider this current flow to be in the same direction as the magnetic flux through the coil. Arrows show the current flow in the circuit, as before.

Obviously, as the movable pointer is moved DOWN towards the center tap on the resistor, the voltage on the top side of the coil will be reduced. This will, in turn, reduce the current flow through the coil. Therefore, the flux will be reduced. If the pointer goes down to the zero position at the center tap, there will be no current flow, and therefore, no magnetic flux. As the pointer moves down past the center tap, towards 0 v., current flow through the coil will be in the opposite direction, thus setting up the magnetic flux in the opposite direction.

Now skip to figure 9. This demonstrates the fact that the potentiometer is a device by which you can govern both the STRENGTH and DIRECTION of the magnetic field or flux about the coil by governing the strength and direction of the current flowing through it. Get it?

Reading the flux vectors from left to right opposite the coil, you see the VALUE and DIRECTION of the voltages across the

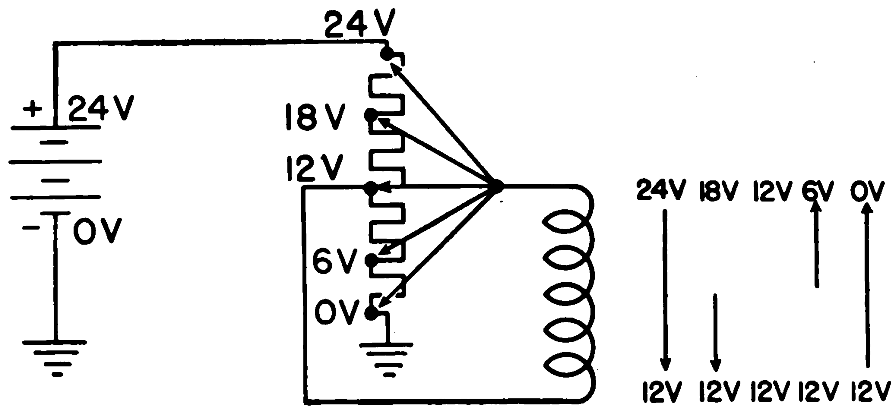


Figure 9.—Voltage values.

coil. This changes as the pointer is moved down from top to bottom of the resistor.

This type of control is applied to aircraft turrets. You will see its direct application soon.

THE AMPLIDYNE ENLISTS

Here's one you'll be seeing a lot of in electric turret work— the amplidyne. That's a trade name meaning "to amplify power." In turret application, the amplidyne provides power for driving the turret motor.

Originally the amplidyne was strictly a peacetime baby. It was designed as a power control amplifier by the General Electric Company for a variety of industrial uses. Then came World War II, and like millions of Americans, the amplidyne joined the service.

It was found to have just the right control features necessary for turret application. Power magnification must be quick, precise, and two-directional in order to permit accurate driving of the turret up or down in elevation and right or left in azimuth. The amplidyne provided this type of QUICK RESPONSE.

To get down to the facts about just exactly what makes up an amplidyne, the first thing you will want to know is that the amplidyne is really a motor generator. It consists of a direct current motor and a direct current generator enclosed in a single housing. The two rotors are pressed on a single shaft, supported by two ball bearings. Electric connections to the amplidyne unit are made through a connector receptacle mounted on the side of the unit.

The amplidyne is similar to any ordinary separately excited generator in that it is a rotating machine which CONVERTS

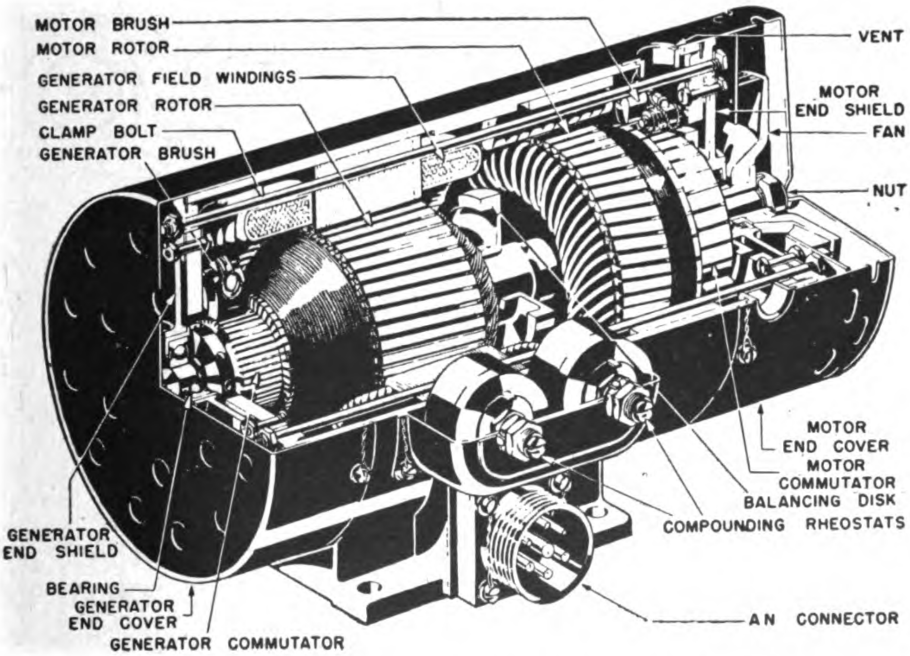


Figure 10.—Amplidyne motor-generator (cutaway).

MECHANICAL ENERGY into ELECTRICAL ENERGY. But it is unlike any rotating machine previously built, in that the amount of excitation is very much smaller.

In other words, the ratio of the power required to excite the control field in relation to the power output is very much less than the corresponding ratio in conventional types of generators. Futhermore, the speed of response is such that a small change in the excitation will produce a relatively large change in the power output within a fraction of a second.

A review of a conventional direct current generator will help you understand the amplidyne operation. Armature reactance flux plays a major role in the amplidyne. Since it is a flux set up by the ampere-turns ratio of the armature, it is also necessary to review the characteristics of a wire carrying a current.

If current is sent through a straight wire as in figure 11*A*, the wire has a magnetic field about it in a clockwise direction. The strength of this field is directly proportional to the current flow.

(To detemine the direction of flux about the conductor, grasp the wire in your right hand with the thumb pointing in

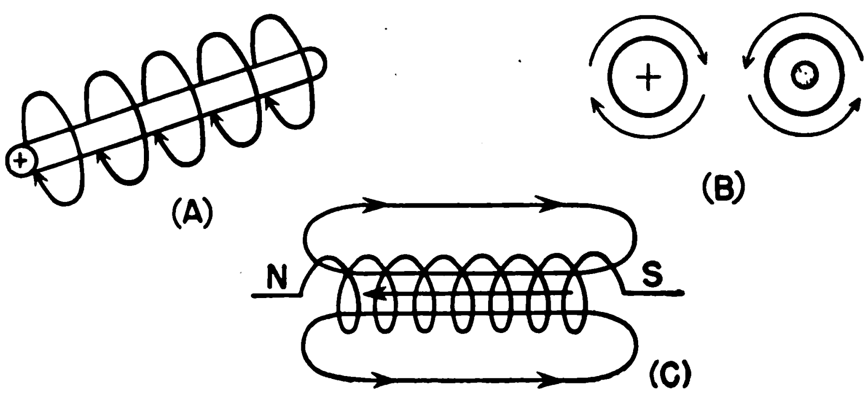


Figure 11.—Magnetic fields.

the direction of the current's flow. Your fingers will then point in the direction of the flux. This is called the "right hand rule".)

Figure 11*B*, illustrates the magnetic field or flux set up by two conductors carrying a current in opposite directions. You can see by this figure that the two fluxes add together to provide a stronger magnetic field than does a single wire.

If the straight wire in figure 11*A* is fashioned into a coil as in figure 11*C*, you find that there is a relatively strong magnetic field set up about the coil when the same amount of current is passed through the wire as in figure 11*A*. This can be explained simply by stating that you have increased the number of lines of force per unit area by making the wire into a coil.

To be more specific, you can see by a cross-sectional view of a coil exactly what is happening. In figure 12 you have such

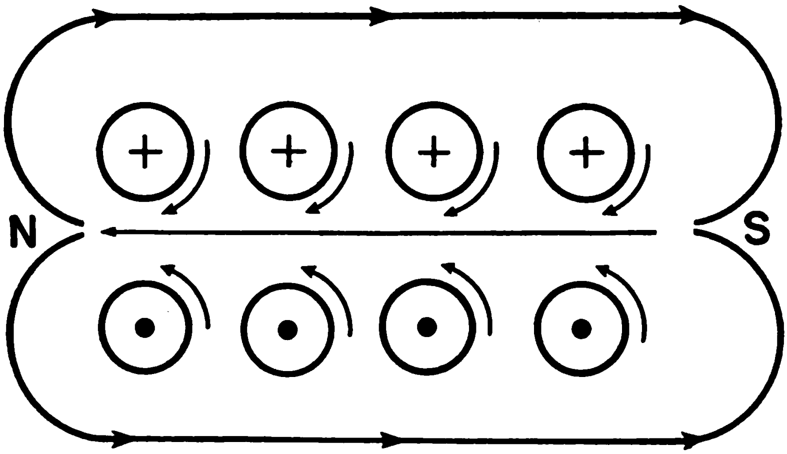


Figure 12.—Cross-section of coil.

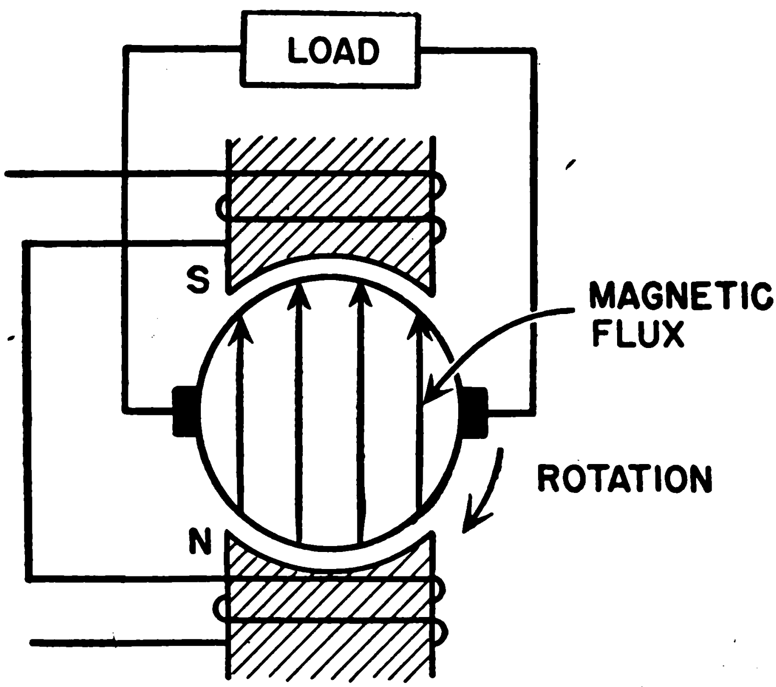


Figure 13.—Conventional generator.

a view. The wire of which the coil is made has small magnetic lines of force around it, and these smaller lines of force tend to aid one another in setting up a relatively large flux.

You see that the coil also has taken on a definite polarity, having both a north and a south pole. On the outside of the coil, magnetic lines of force are said to "flow" from the north pole to the south pole, while on the inside they flow from the south pole to the north pole to complete the magnetic circuit. In the study of the amplidyne, keep in mind that the armature actually consists of coils of wire, and consequently has all the characteristics of a coil of wire carrying a current.

Now consider the characteristics of a conventional generator. Figure 13 illustrates such a generator having a rotating armature, a magnetic field, and load brushes at 90 degrees to the field flux, connecting the generator to the load. Though there are many conductors in the armature, you will consider the action of only one conductor in each quadrant of the armature. Only these four need be considered because the remaining conductors in each quadrant will be doing the same thing as the representative conductor in the corresponding quadrant. By determining what these four conductors are doing, you easily can see how the generator functions.

Figure 14*A* is a simplified drawing of figure 13. It shows how induced current in the armature conductors results from the conductors cutting the magnetic field about the armature.

This induced current flows from the generator to the load, and back through the armature, completing the electrical circuit.

Take a look at figure 14*A*. You can see that when these conductors carry this current, small magnetic fields are set up about each conductor. These small magnetic fields work together. They aid one another in setting up a relatively large field in the same manner in which the large magnetic field was produced in the coil in figure 12.

The flux is known as an armature-reactance flux, and is not desirable in the conventional generator. It tends to distort the original field flux, and therefore shift the commutating plane (the position where the brushes can take off maximum induced current). Compensating windings are usually employed to set up another flux to neutralize this effect.

Here's where the amplidyne differs from the conventional generator. The amplidyne UTILIZES this armature-reactance flux to good advantage. In figure 14*B*, vectors representing the fluxes are shown. Vector *A* represents the original field flux, and vector *B* represents the armature-reactance flux.

In figure 15*A*, the conventional generator is shown with the load removed from the circuit, and a straight wire short-circuiting the two brushes. Naturally, if the brushes of a conventional generator become shorted when the full field strength is

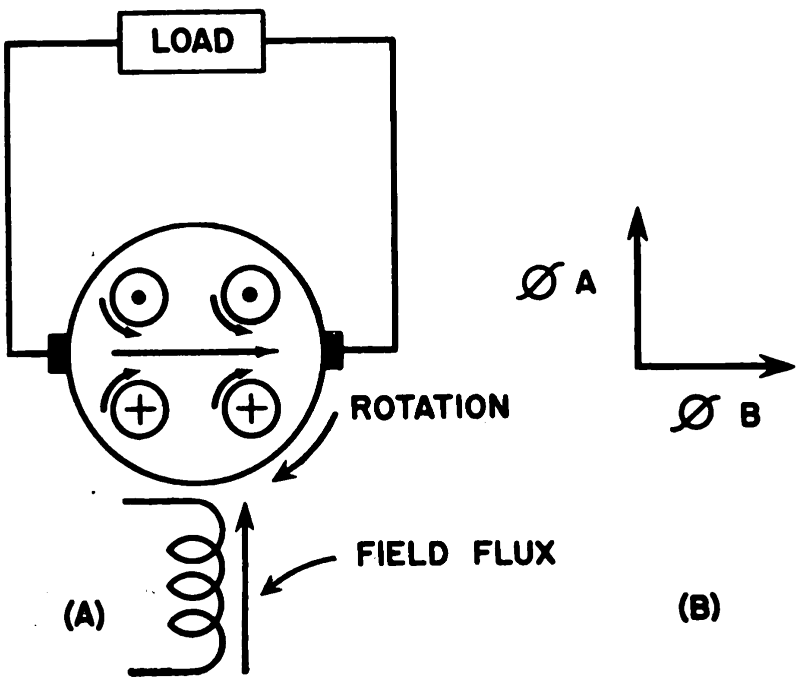


Figure 14.—Armature reactance and vector analysis.

being used, the wire or the armature itself will be burned up because there will be an excessive flow of current through them.

How to prevent this? Note in figure 15*B* that the field flux *A* has been reduced greatly. As the amount of generated voltage depends upon the number of lines of force cut per unit of time (speed of rotation of the armature and density of field), it is evident that a reduction in flux *A* will reduce the amount of generated voltage at the brushes. This low generated voltage will not send enough current through the short circuit wire to burn it out.

Why, then, is flux *B* still shown as a large or perhaps even larger flux than before? You remember that a magnetic field depends upon the "ampere-turns ratio" of the coil. As the number of conductors on the armature (turns) has not changed, this indicates that the current flow through the armature must be relatively large.

Part *C* of figure 15 is a sketch of this short circuit. When the original flux *A* was decreased as in part *B* of the illustra-

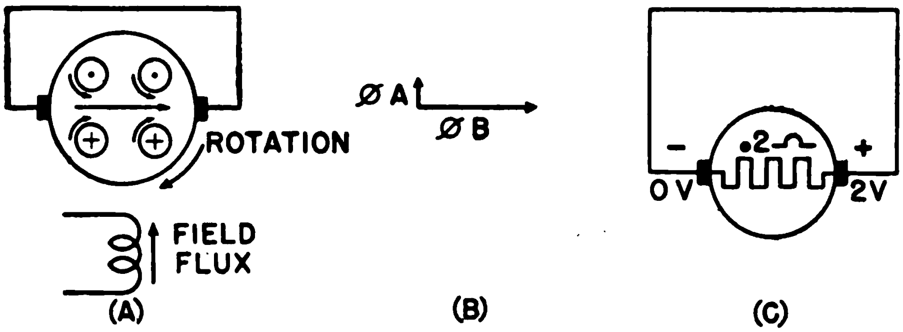


Figure 15.—Generator with brushes short circuited.

tion, the generated voltage at the brushes was likewise decreased to approximately 2 v. The resistance of the short circuit is very low, having only brush and armature resistance.

Therefore, there will be a relatively high current flow in the short circuit even though the generated voltage is small. By using Ohm's Law and the figures above, you can compute the current flow. The resistance of the armature is approximately .2 ohms.

$$I = \frac{E}{R} \qquad I = \frac{2\text{ v.}}{.2\text{ ohms}} \qquad I = \frac{20}{2} \qquad I = 10\text{ amps.}$$

If 10 amperes is the current flow in the short circuit and the armature, the relatively large armature flux *B* as shown in figure 15*B* will be produced because the ampere-turns ratio of the armature is relatively high. This armature flux has been labeled the "short-circuit-axis flux."

This short-circuit-axis flux RETAINS A FIXED POSITION. It DOES NOT ROTATE with the armature.

Because this flux remains stationary, the conductors must cut these lines of force as they rotate about the armature axis.

Engineers experimented with this flux, and learned that if brushes are placed at 90 degrees to it, a generated voltage, dependent upon the size of the short-circuit flux, can be taken off for a load circuit.

A CROSS-AXIS GENERATOR DOES IT!

The generator designed to accomplish this is called a CROSS-AXIS-EXCITED generator or METADYNE generator. It has two distinct advantages over the conventional generator.

They are —

Exceptionally small field currents are required to produce the full output voltage.

The voltage builds up to its final value in an exceedingly short time.

Part *A* of figure 16 shows the brushes placed at 90 degrees to the short-circuit flux. The short-circuit-axis flux is shown on the outside, left of the armature, so you can see more clearly the action of the conductors with respect to this flux.

By using the right hand generator rule, you can determine the direction of induced current in the armature conductors with respect to the short-circuit-axis flux. You see that when current is taken off to the load, this current flowing through the arma-

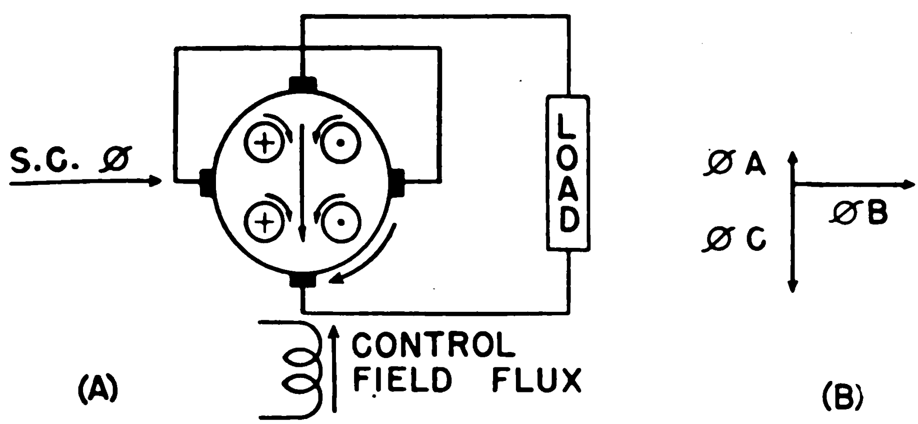
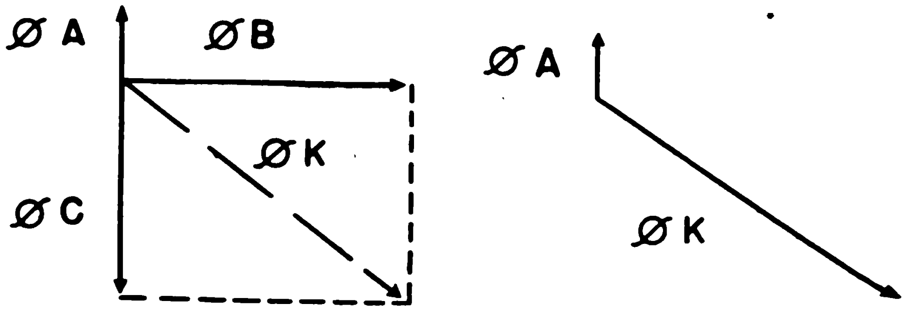


Figure 16.—Load circuit added.

ture sets up another armature-reactance flux in direct opposition to the original control-field flux. Figure 16*B* shows a vector diagram of the fluxes now involved. The new armature reactance flux *C* is set up by the load current flowing through the armature, so it will now be referred to as the LOAD-AXIS FLUX.

Figure 17*A* shows a vector diagram of these fluxes. Since a VECTOR, as you know, represents both magnitude and direction of a flux, you can see that the load-axis flux will distort



(A) (B)

Figure 17.—Flux vector diagram.

the short-circuit flux so that you will actually have neither of these fluxes, but an effective resultant flux of the two. With this condition existing, part *B* of figure 17 shows the effective flux characteristics. If the load-axis flux DISTORTS the short-circuit flux, resulting in flux *K*, the load brushes will not be in the proper plane for correct commutation (90 degrees to flux). This resultant also will distort the ORIGINAL control field, thus making conditions even worse!

It is apparent that the amplidyne will be WORTHLESS as long as the resultant flux exists, because the output of the amplidyne will be low. This makes the load-axis flux a "nuisance" flux, and one that you must NEUTRALIZE. Being unable to eliminate this load flux, you can OPPOSE IT with an equal flux and destroy its harmful effects.

MORE FLUXES

In figure 18*A* you will note that a field (*D*) has been wound in series with the load circuit, and in such a manner that the flux it creates OPPOSES the load-axis flux. The current going to the load (turret drive motor) creates both the load-axis flux and the new flux, which is known as the SERIES-COMPENSATING FLUX, for they are in the SAME CIRCUIT.

If the current flow to the turret drive motor (TDM) should increase, both the load-axis flux and the series compensating flux will increase SIMULTANEOUSLY. From this, you can assume that if the series-field flux is made EQUAL to the load-axis flux for any given current flow in the load circuit, it will decrease and increase EQUALLY with the load flux as it changes.

In this manner, you have an automatic means of controlling the load-axis flux over a relatively wide range of current values.

How about a brief review of the fluxes and their purposes?

First, there is the externally-excited control-field flux which is controlled by the amount of potentiometer deflections. As you increase this flux, you increase the short-circuit flux. As the short-circuit flux increases, the generated output of the

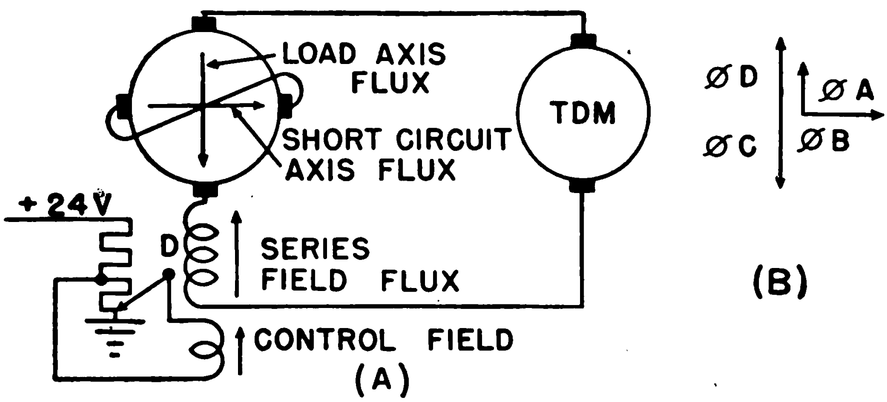


Figure 18.—Series field added.

amplidyne increases. With this increased output, the TDM (which is the load) will increase in rpm, and the turret will move faster. The current to the TDM also passes through the amplidyne armature, and the load-axis flux is set up. Its effects are cancelled by the series field, which builds up at the same instant.

In brief, the purpose of the control field is to set up the short-circuit-axis flux. The purpose of the short-circuit flux is to allow a voltage to be generated to drive the TDM. The load-axis flux has no purpose, but it does have ILL EFFECTS. The purpose of the series-field flux is to oppose the load-axis flux, and effectively cancel its ill effects. Figure 18*B* is the complete vector analysis of the amplidyne fluxes, indicating the magnitude and direction of fluxes and their relation to one another.

OK? Run through this brief review of fluxes again if you don't understand them. They're IMPORTANT.

WHY THE AMPLIDYNE?

Why couldn't you use an ordinary generator instead of an amplidyne to drive the TDM?

Because the ordinary generator doesn't furnish a quick enough RESPONSE. Take this example —

The resistance of the control field is approximately 30 ohms. If .5 v. is impressed across the control field there will be .5/30 or 1/60th of an ampere flowing through the field coil. With the amplidyne rotating at 8,300 rpm, this field flux will allow about 2 v. to be generated at the short-circuit brushes. If the resistance of the armature is .2 ohms, there will be 2 divided by .2, or 10 amperes, flowing in the short circuit.

This may be called the FIRST STAGE of amplification. The 10 amps. flowing in the short circuit set up enough armature flux to produce 20 v. across the load circuit for the second stage of amplification.

Starting out with .5 v., it was amplified to 20 v. with the amplidyne. Figure 19 indicates these generated voltages. This in itself is not as important a factor as is the time element involved for changing quickly from one generated voltage to another. For each .1 v. across the control field, there are about 4 v. generated output. If you reduce the control .1 v. (from .5 v. to .4 v.), the output will drop to about 16 v. (a drop of 4 v.) in a fraction of a second.

From this you can get an idea of how an infinitely small change in the CONTROL FIELD can cause a relatively large change in the GENERATED OUTPUT. As the speed of the TDM is proportionate to the generated output of the amplidyne, the speed will DECREASE as the generated output decreases, and INCREASE as the output is increased.

If this decrease and increase in speed of the TDM is to be INSTANTANEOUS, as it must be for a turret, the generated output must change instantaneously.

Therein lies the secret to AMPLIDYNE CONTROL of aircraft turrets.

The quick, instantaneous response characteristic of the amplidyne is its most important feature. If the potentiometer is deflected clockwise for full HIGH SPEED, the turret will rotate clockwise at that speed. If you wish it to rotate at the same speed in the OPPOSITE DIRECTION (counterclockwise), quickly deflect the potentiometer for counterclockwise rotation at full high speed. The polarity of the generated output changes instantly and the turret QUICKLY RESPONDS.

You know that when you change deflection of the potentiometer the control field becomes REVERSED. This causes all the other fluxes and the output of the amplidyne to REVERSE in-

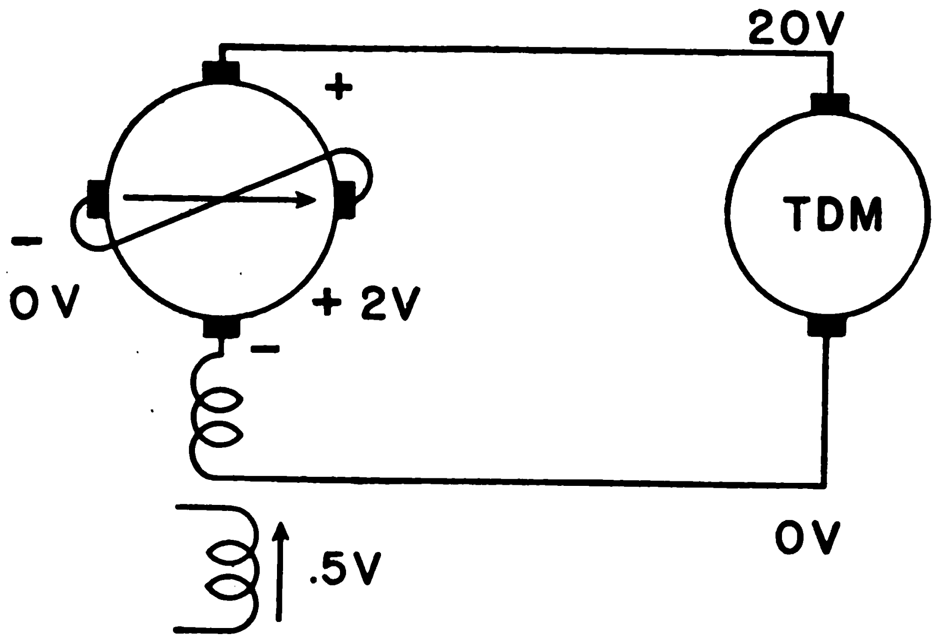


Figure 19.—Generated voltages.

stantly. With this output reversal, the TDM must reverse rotation also, because its field flux remains stationary and its armature flux reverses.

Now, what about an ordinary generator?

An ordinary generator is unable to reverse its output or change its generated output value as QUICKLY as the amplidyne. Its control field is MUCH TOO LARGE to reverse instantly, and small variations in this field will not cause relatively large changes in the output. Because the field excitation is large, it would be difficult to design a small, sensitive, control device for the ordinary generator. True, an ordinary generator could

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be used, but the turret would be SLOW TO REACT. And its overall efficiency would not nearly equal the SMART PERFORMANCE given by the amplidyne.

OTHER FIELDS

There are two other fields wound in the amplidyne that have not been mentioned. These are the SERIES-QUADRATURE FIELD and the ANTI-HUNT FIELD.

The series-quadrature field is a short-circuited field. It aids in smoothing out any ripples in the generated output due to commutation irregularities.

The anti-hunt field acts as a stabilizer in the amplidyne system. The action of this field will be given in detail in the explanation of the anti-hunt circuit later in this chapter.

Thus, there are six separate fluxes in the amplidyne — two of them armature-reactance fluxes (short-circuit flux and load-axis flux). The remaining four are produced by windings on the generator pole pieces. The control field is wound on the top pole piece, together with half the series field and two coils of the quadrature field. On the bottom pole piece the anti-hunt field is wound, together with the other half of the series field and the other two coils of the quadrature field.

AMPLIDYNE MAINTENANCE

Whenever the amplidyne is being disassembled or assembled, the brushes on both ends must be tied or blocked up, or they will be sheared and break.

Do NOT OVER-TIGHTEN the four nuts holding the end shields. Otherwise, the threads may be stripped or the frame bent. The through-bolts must be properly positioned, or they will obstruct the fan or generator end cover.

Amplidyne motor-generator brushes are expected to last 15 to 100 hours in operation, depending on the amount of turret movement, altitude of operation, temperature, humidity, and other factors. They wear much faster at high altitudes. It is recommended that the brushes be inspected at least every 50 hours of turret operation, and preferably after each time the turret has been in combat.

Inspect the commutators at the same time for excessive dirt, burning, or pitting.

Brushes should be replaced when they are worn to within ⅛ inch of the metal brush holder. You'd better change all brushes if one or two of them are worn to this extent. This helps you avoid frequent disassembly.

When you replace brushes, the amplidyne motor-generator set should be removed from the turret, of course.

Cut safety wire, loosen screws, and remove the old brushes. DON'T LOOSEN THE INNER FOUR NUTS WHICH HOLD THE BRUSH YOKE TO THE END PLATE OF THE AMPLIDYNE. This is a critical setting made at the factory.

Insert new brushes, and adjust shim washers so that when the screws are tightened snugly, the safety-wire holes will be aligned for safety wiring. DO NOT TIGHTEN SCREWS TOO MUCH OR BRUSHES WILL BREAK. Replace safety wire, looping it through the hole in the screw and around the brush holder.

Prepare a thin strip of #0000 sandpaper and apply to the commutator with scotch tape. BLOCK THE BRUSHES UP, reassemble the armature to the end shield, release the brushes so they hit the sandpaper, and turn the armature until the brushes are sanded into as close a fit as possible. The brush fit is extremely important in the case of the generator end, because of its critical effect upon amplifications.

Remove sandpaper, and THOROUGHLY clean the armature, commutators, both brush riggings, and field frame with compressed air. There will be carbon and dust deposits and it is important that you get rid of them.

Reassemble the amplidyne.

Run the amplidyne at light load for five hours, or at least until the generator-end brushes fit. The use of brush-seating stones is NOT recommended.

Do not oil or lubricate the commutators in any way.

If it is necessary to clean the commutators, they may be sanded lightly with #0000 sandpaper. Do this on a lathe. DO NOT USE EMERY CLOTH. Blow out all dust afterwards.

If a commutator is badly scored or burned, it is permissible to take a LIGHT lathe cut. Following this, you should under-cut the mica between segments 1/32 inch, using a piece of hacksaw blade ground to proper thickness. After this, the amplidyne must be run for several hours to reshape the brushes.

The bearings are sealed with grease, and don't need to be lubricated further. If bearings are found to be binding, remove them with a bearing puller and replace. It is not necessary to rebalance the armature after replacing bearings.

Rewinding of faulty armatures or fields as NOT RECOMMENDED. The assemblies should be replaced instead.

TURRET MOTOR DRIVE

You should be on friendly terms with ELECTRIC MOTORS. Since the days of your first memories, you have seen them turn the blades of electric fans, run the family washing machine, and do other common tasks.

The electric turret has two drive motors — one to drive the turret in ELEVATION AND DEPRESSION, and one to drive the turret in AZIMUTH or TRAIN. Each of these turret drive motors receives its operating power from its respective amplidyne. The TRAIN AMPLIDYNE supplies power for the train turret drive motor, and the ELEVATION AMPLIDYNE supplies power for the elevation drive motor.

The turret drive motor, or TDM as it is commonly called, is known as a "separately-excited" motor. This term is applicable because the armature and the field of the motor are excited (energized) from different sources of power.

Direction of rotation of a d.c. motor can be changed by reversing either the armature flux or the field flux. If both the field flux and the armature flux are reversed simultaneously, direction of rotation will remain the same.

An ordinary shunt or series d.c. motor cannot be used on the turret because the field flux is reversed whenever the armature excitation is reversed. If one of these two types were used, the turret would run always in ONE DIRECTION regardless of the polarity of the amplidyne output.

It wouldn't be much good, would it?

On the turret, the TDM field is constantly excited from the aircraft power source, and the armature excitation is changed to reverse the rotation as the amplidyne output reverses. You get QUICK response in TWO directions.

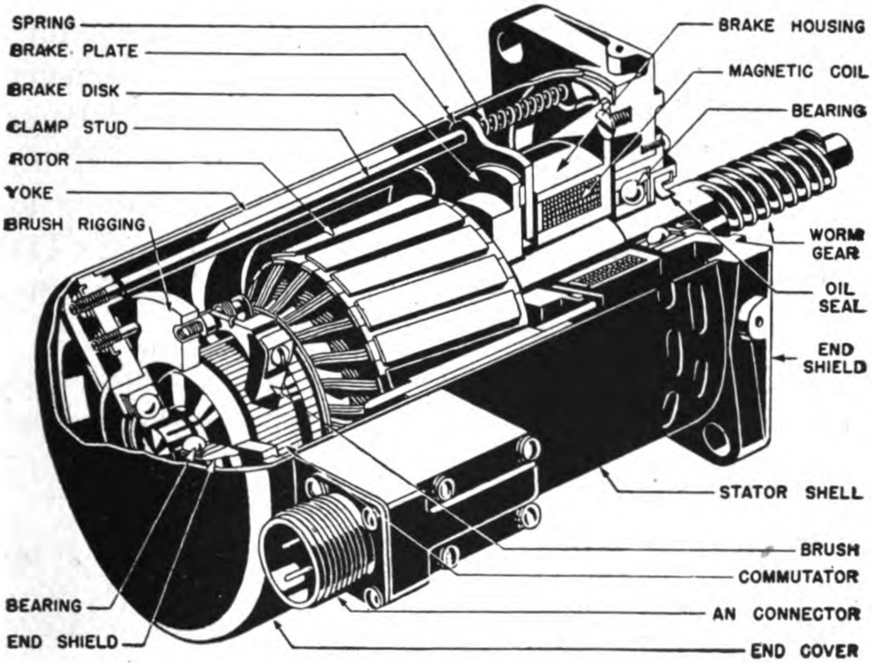

Figure 20.—TDM (cutaway).

CHANGING DIRECTIONS

Here's what happens.

Figure 21*A* shows a motor having a separately-excited field. with 20 v. impressed from battery *A* across the motor armature. The field is excited from battery *B*. Rotation is in a clockwise direction.

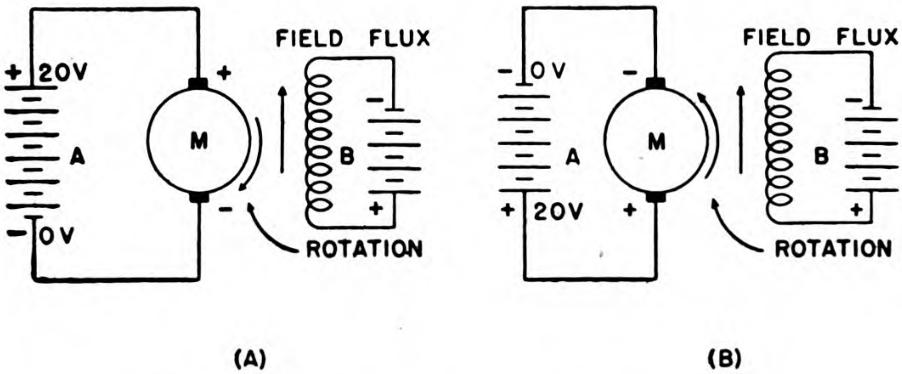

Figure 21.—Motor with separately-excited field.

When polarity of the armature excitation is reversed, as in figure 21*B*, the field excitation remains the same. But you'll note that the direction of rotation has changed to a counter-clockwise direction.

Figure 22 is a simple schematic diagram of the turret as developed so far. When switch *A* is closed, the compound-wound amplidyne drive motor (ADM) begins rotating. It drives the amplidyne generator (AG) at a speed of 8,300 rpm. Rotation of these armatures is always in the same direction.

The potentiometer and the turret drive motor field (TDMF) are energized also when switch *A* is closed. If the movable potentiometer is deflected, the turret operates.

Figure 22 shows the potentiometer in a deflected position, and the control field excited. At full deflection of the potenti-

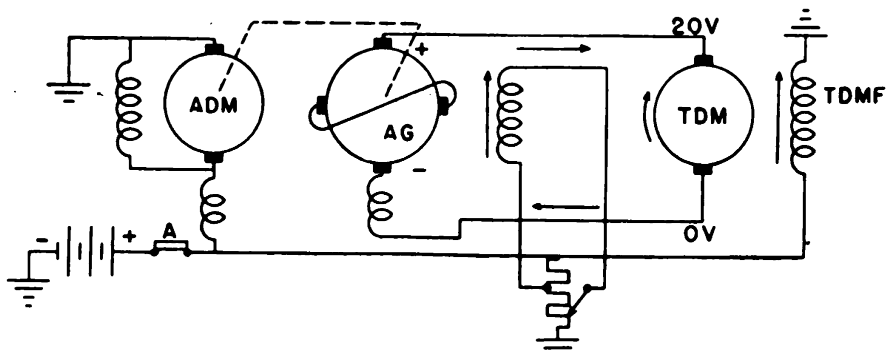

Figure 22.—Schematic diagram of turret.

ometer, the amplidyne output will be approximately 20 v. This will cause the TDM to rotate the turret at a speed of one revolution in 18 seconds. This speed is known as "full normal speed," or the maximum speed for the turret in normal operation.

Figure 23 shows what happens when the potentiometer movable pointer is deflected in the opposite direction. First, the control-field flux REVERSES. This reverses the short-circuit flux, which causes the polarity of the generated output to reverse. Thus reversed, generated output will cause current to flow in the opposite direction (to that in figure 22) through the TDM armature. This causes the TDM to reverse rotation.

Fundamentally, the schematics shown in figure 22 and figure 23 are the actual circuits in the turret — all that is needed

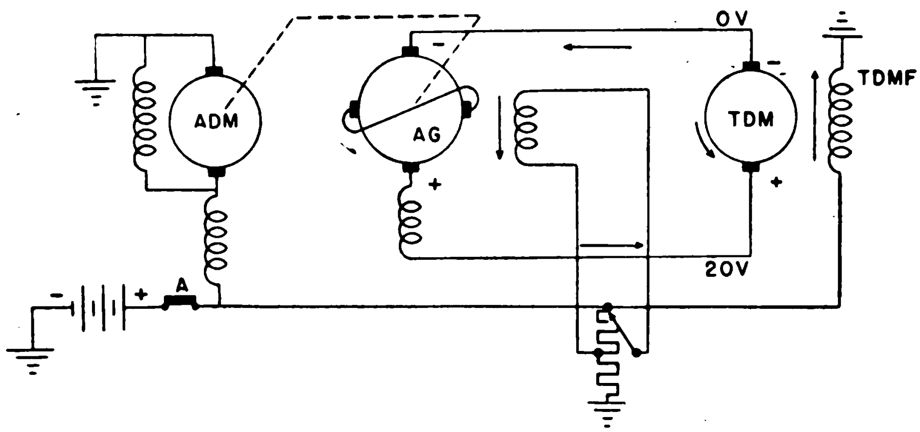

Figure 23.—Opposite potentiometer deflection.

for the turret to operate. For more satisfactory operation, there are several refinements and several additional circuits added to this system.

FEEDBACK VOLTAGE CIRCUIT

You know that the potentiometer controls the flow of current through the control field. The speed of the TDM is proportional to the size of the control field, for all the other fluxes

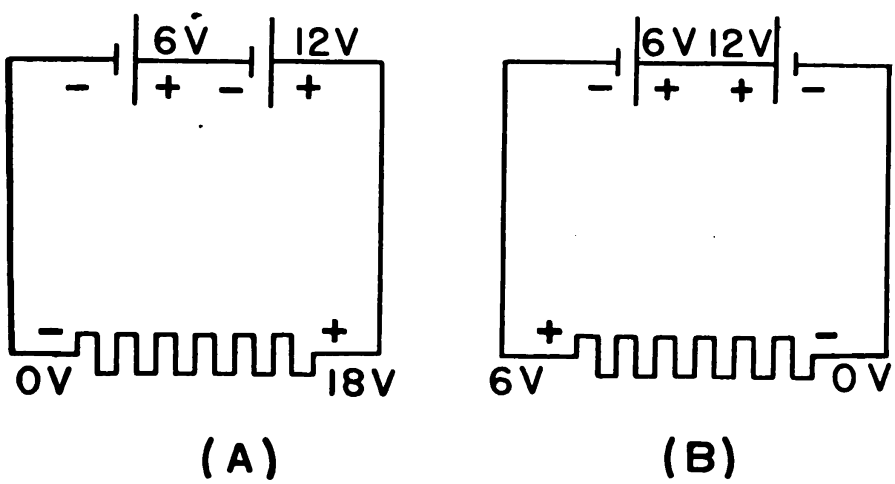

Figure 24.—Aiding and opposing voltages.

in the amplidyne originate from conditions caused by control-field excitation, and their size or strength is dependent upon the control field.

You learned previously that the amplidyne needs VERY LITTLE field excitation. At the fastest speed of the turret, it need be only 2 v. Why then have a potentiometer that puts out 12 v. when only a maximum of two volts is necessary? A good question. But you'll learn that the 12 v. output of the potentiometer is necessary, and that the excess voltage is controlled by what is known as the feedback voltage circuit.

This FEEDBACK VOLTAGE CIRCUIT is often referred to as "bucking voltage." It's used to allow the turret to be more sensitive to changes in potentiometer deflections (acceleration), and to act in the capacity of a voltage regulator for the system.

Figure 24*A* is a diagram of two batteries hooked in series with a resistance load. Their voltage will be ADDITIVE, and a

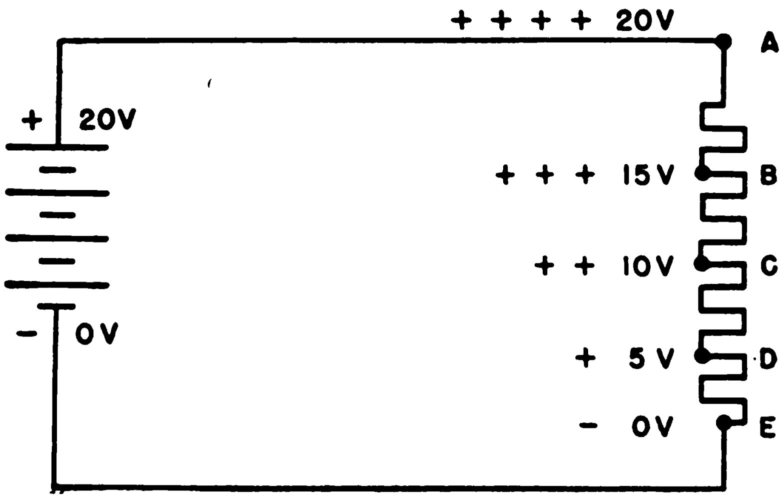

Figure 25.—Voltage divider.

voltage of 18 v. will be impressed across the resistor. Part *B* of figure 24 shows the same two batteries hooked up differently. Their positive plates are hooked together so that their voltages oppose one another. The larger battery (12 v.) will predominate, but the smaller battery (6 v.) will oppose 6 v. of the 12 v. battery. The resultant or effective voltage which is impressed across the resistor is 6 v. This principle as applied to the aircraft turret is known as feedback (opposing) voltage.

Figure 24 shows a battery with an output of 20 v. hooked to a resistor load. You learned that a resistor can be used as a VOLTAGE DIVIDER, and that the effective voltage at a certain point is WITH RESPECT to some other point in the circuit.

Thus, the voltage at point *B* with respect to point *D* is 10 v., but 15 v. exists at point *B* with respect to point *E*. Also you see that point *B* is positive (+) with respect to points *C, D,* and *E,* but is negative (—) with respect to *A.*

By this, you readily see that when a current is sent through a resistor, the resistor takes on a definite voltage value (IR drop), AND a definite polarity. With this condition existing,

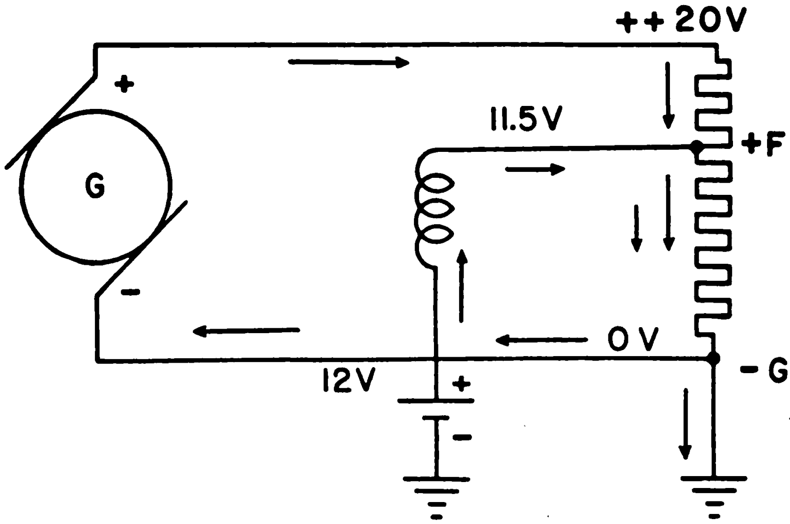

Figure 26.—Current returning to source.

you may tap any part of this resistor, and use its polarity and voltage value to oppose another voltage.

In figure 26, you have two separate sources of power (generator and battery), with both using the resistance FG as a

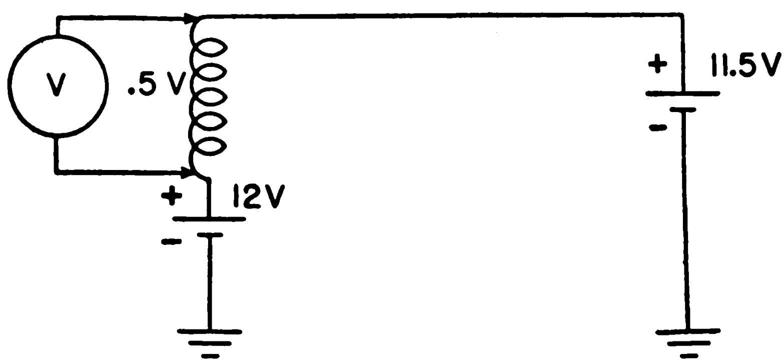

Figure 27.—Battery analogy.

common path. The generated voltage (20 v.) sends a current down through the resistance and back to the generator.

The topside of the coil is tapped on the resistor at point *F* where 11.5 v. exist with respect to point *G* (0 v.). As there is a complete path from *F* through the coil and the 12 v. battery to the ground, and back through point *G* to the minus (—) terminal of the generator, the + 11.5 v. will act to oppose the 12 v. of the battery.

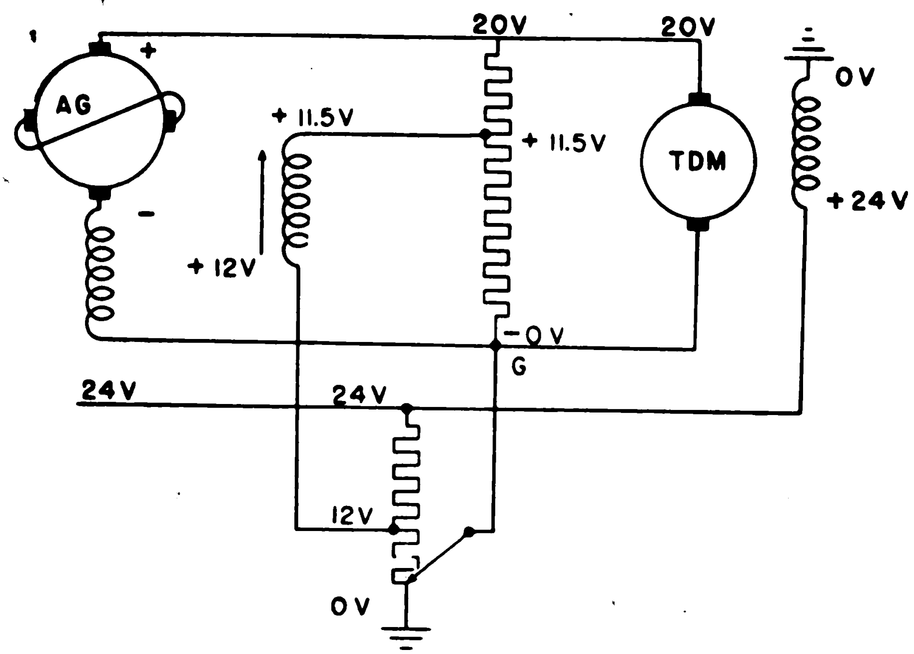

Figure 28.—Application to turret.

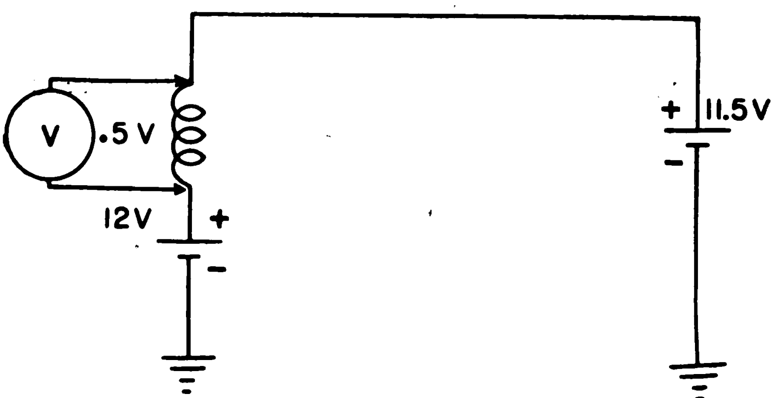

Figure 29.—Battery analogy of figure 28.

It must be understood that all of the current leaving a source of power will return to the source. Therefore, all of the current leaving the battery in figure 26 will return to the battery, and all of the current LEAVING the generator will RETURN to the generator.

Now take a look at figure 27. It illustrates a battery analogy of the coil circuit in figure 26. The 11.5 v. battery represents

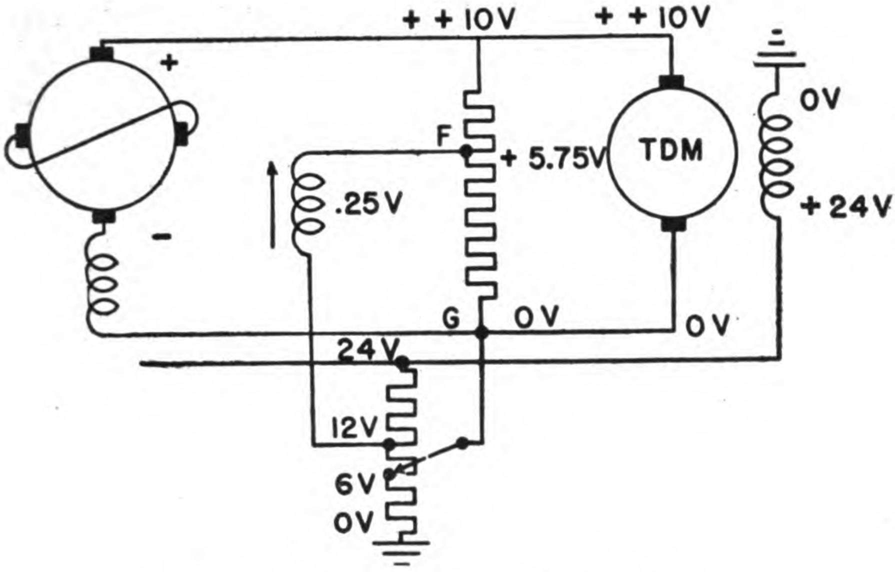

Figure 30.—Potentiometer at half deflection.

the FEEDBACK VOLTAGE VALUE opposing the 12 v. battery. The feedback voltage is a fraction of the generator output voltage. It is connected in series with the control field circuit.

HOW ABOUT THE APPLICATION OF THIS PRINCIPLE TO THE TURRET? That's what figure 28 shows. The feedback voltage resistance circuit has been placed across the output of the amplidyne, and the control field has been connected to it. With the potentiometer at full deflection, you need approximately .5 v. across the control field to produce 20 v. generated output.

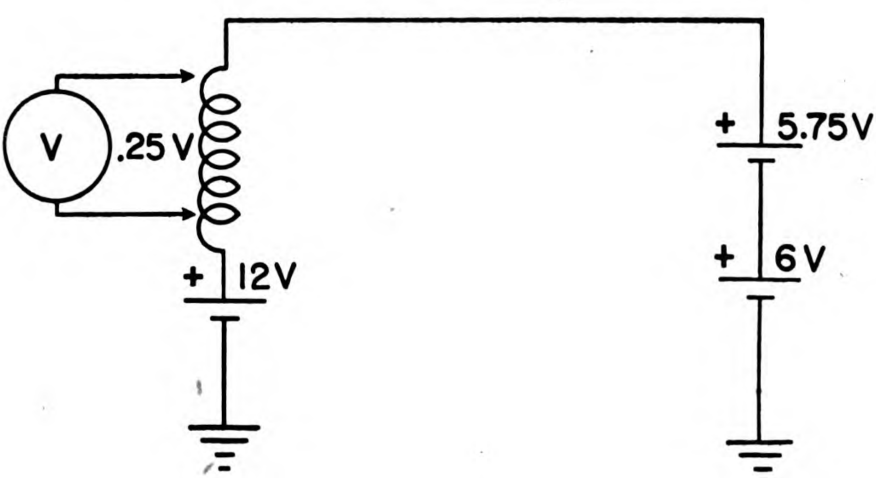

Figure 31.—Battery analogy of figure 30.

With 12 v. coming from the potentiometer, you'll need 11.5 v. feedback voltage.

Figure 29 is a battery analogy of the control field circuit in figure 28. The 12 v. battery represents the +12 v. (with respect to ground) at midtap on the potentiometer, which is sending current up through the control field. The 11.5 v. battery represents the feedback voltage which is the IR drop across "FG."

WHAT HAPPENS WHEN THE POTENTIOMETER IS BROUGHT TO HALF DEFLECTION? Well, first the output of the amplidyne drops to 10 v., because the potentiometer is not sending as much current through the control field. When the output voltage drops (to 10 v.), the voltage at point *F* drops proportionately to 5.75 v.

By this, you can see that there is an "effective" 6 v. (difference between 12 v. and 6 v.) from the potentiometer and 5.75 v. feedback voltage. Thus, the IR drop across the control field is 6 v. minus 5.75 v. or .25 v. (this is half of .5 v., used for full normal speed).

Figure 31 shows the battery analogy of the deflection. The 12 v. battery represents the voltage at the midtap of the potentiometer, while the 6 v. battery represents the 6 v. at the

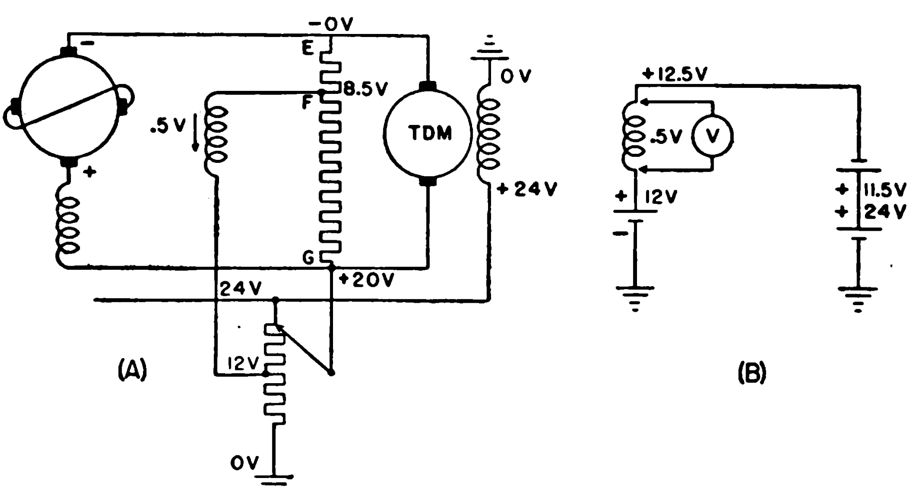

Figure 32.—Potentiometer fully deflected.

point where the potentiometer pointer is touching. The 5.75 v. battery represents the feedback voltage. Thus, the 12 v. battery in effect has to overcome both the 5.75 v. and 6 v. potentials.

This leaves only .25 v. for control field excitation, the voltage for half full normal speed operation.

Now for an analysis of FULL potentiometer deflection. Figure 32*A* indicates the voltage values when the potentiometer is fully deflected in the opposite direction. With this deflection, the control field and the generated output reverse. At point *G*, 20 v. exist with respect to point *E*, but only 11.5 v. exist there with respect to point *F* (20 v. — 8.5 v.), where the control field wire is connected. This is the feedback voltage, opposing the effective 12 v. (24 v. — 12 v.) from the potentiometer and leaving only .5 v. drop across the control field.

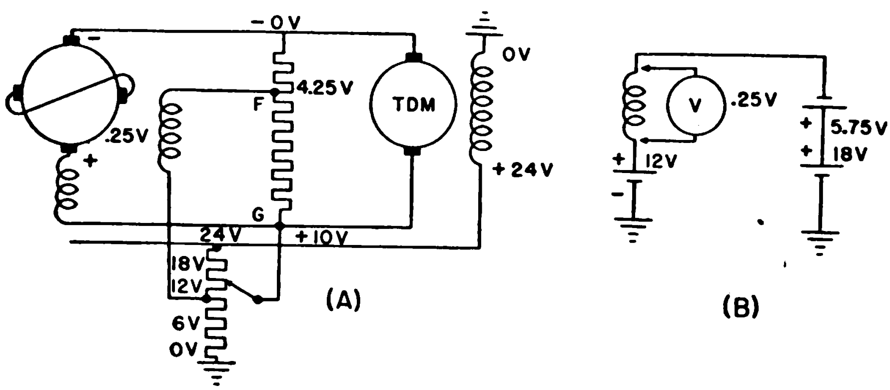

Figure 33.—Potentiometer at half deflection.

Figure 32*B* is a battery analogy of the control field circuit in part *A* of the illustration. REGARDLESS OF THE POTENTIOMETER DEFLECTION, it is the IR drop across the resistance "FG" that is used as the FEEDBACK VOLTAGE.

Figure 33 shows what happens at half potentiometer deflection on the top side of the potentiometer resistance.

This feedback voltage aids in making the turret MORE SENSITIVE to control.

How? Consider what happens when the potentiometer is deflected suddenly from neutral position to full deflection. When the potentiometer is at neutral, there is no control field excitation, and no generated output, AND therefore, no feedback voltage.

When the pointer is moved suddenly from "x" to "y," as in figure 34*A*, for a fraction of a second, there is no feedback voltage. Thus, the resistance "FG" has no voltage value or polarity. The control field current will encounter only the ohmic resistance value of "FG." Because the TDM and the resistance "EF" are in parallel with "FG," the effective resistance will be less than 100 ohms.

Part *B* of figure 34 indicates the effective control field circuit for the first fraction of a second. Approximately 3 v. across the control field for this instant will cause the control field to BUILD UP quickly — and allow the generated output to build up fast, too.

As the generated output builds up, current flows through the feedback circuit. "FG" takes on a definite voltage value

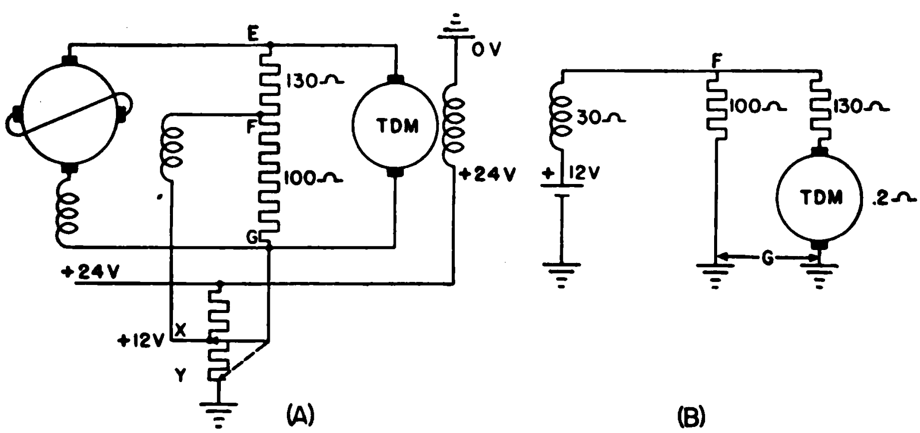

Figure 34.—Sudden deflection.

and polarity. This causes the control field voltage to drop back to .5 v. and stay there.

FOLLOW IT? The voltage across "FG" is a fraction of the output of the amplidyne, and it will be determined by the voltage across the control field so that normally it opposes the potentiometer voltage. As the potentiometer is moved away from a neutral position, the voltage across the control field is high. As soon as the generated voltage begins to rise, the voltage "FG" opposes the potentiometer voltage, thereby reducing the control field voltage. A stable point is reached at which the difference between the potentiometer voltage and feedback voltage produces a control field just large enough to maintain the desired amplidyne generated voltage.

Now that you know why the voltage value of "FG" is greater than its pure resistance (ohmic) value, you should get ideas about how to change the speed of the turret.

YOU FIX IT

Suppose the control field wire at point *F* in figure 35 becomes accidentally disconnected, and you were told to fix the turret. How would you know where to solder the wire back

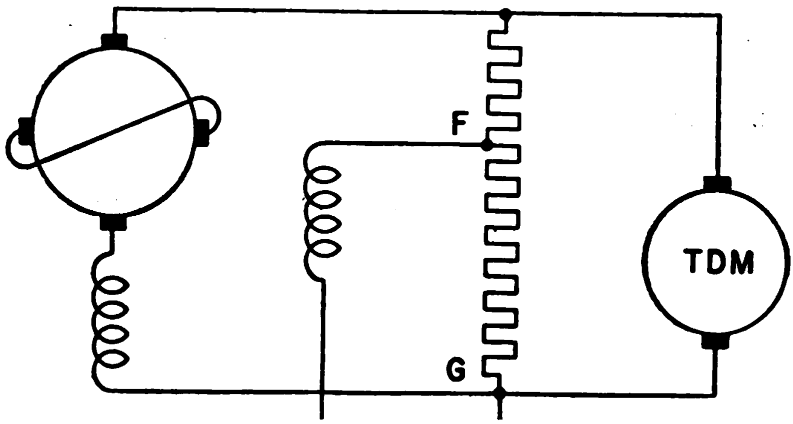

Figure 35.—Connection of control field wire.

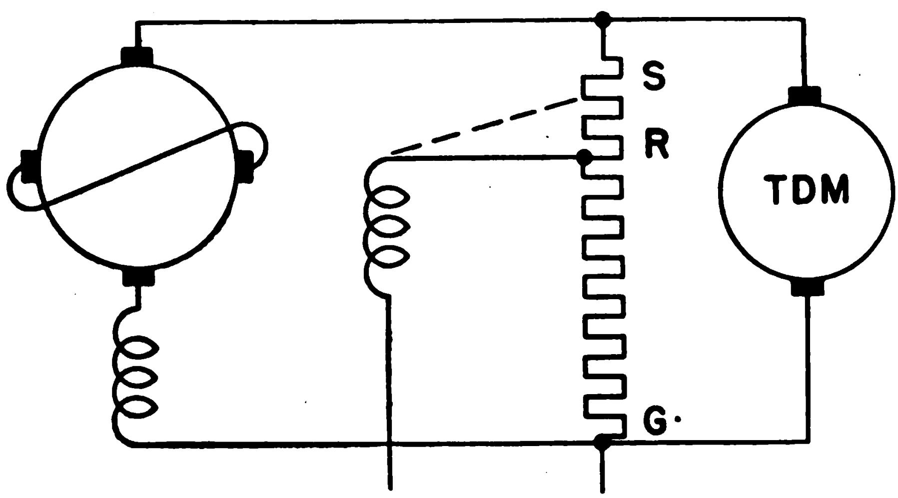

Figure 36.—Adjusting for speed.

on the feedback resistance if there was no solder on the resistor to betray where the wire belonged?

A voltmeter won't measure 11.5 v. on the feedback resistance, for it has no voltage value until the control field is excited. The control field cannot be excited, for its lead is disconnected.

The speed of the turret is your main concern. At full deflection of the potentiometer pointer in train normal speed operation, you know the turret should rotate 360 degrees (one revolution) in 18 seconds. And here's how you can get that speed.

Take the control field wire, and connect it at some point *R*, as in figure 36, on the feedback voltage resistance (FBVR). Then deflect the potentiometer for full normal speed. Use a stop watch to determine how many seconds it takes the turret to rotate one complete revolution. Suppose that the turret makes one revolution in 16 seconds without "guess setting." This is too fast by two seconds, and you want to correct it. Now comes the problem of which way to move the control field wire on the FBVR.

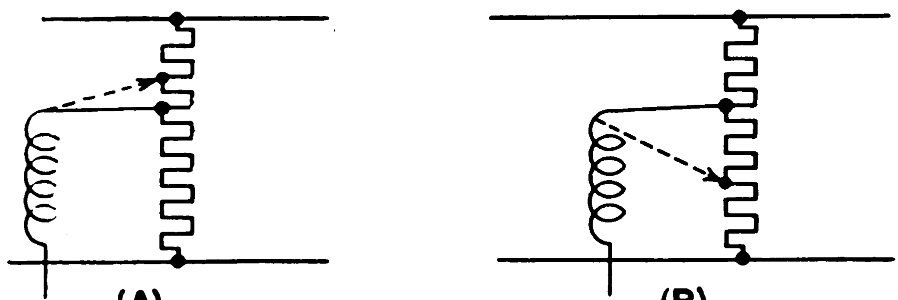

Figure 37.—To decrease and increase normal speed.

Since the turret is running too fast, this indicates that the generated voltage is too high and means that the control field is too large. OK. You move the control field wire so that more FBVR is in series with the control field. This shows in figure 36, where the wire is moved from point *R* to a new point *S*, increasing the FBVR.

Now check turret speed again by the stop watch. If it is too slow, the control field wire has been moved too far from point *G*. If it's still fast, the control field wire has not been moved far enough. In other words, speed adjustments are made by trial and error.

Remember —

To decrease the speed of the turret, increase the FBVR in series with the control field.

To increase the speed of the turret, decrease the FBVR in series with the control field.

PUTTING HER IN HIGH

Over the interphone you hear, "Two bogeys coming in off' the starboard bow at two o'clock high." If you're a turret gunner getting that message, you want your turret to swing FAST.

That's when "normal speed" operation, and such considerations go over the side. And that's when HIGH SPEED OPERATION comes into its own.

Fortunately, there's a handy little button the gunner can push to shove his turret into "high." How does it work?

Well, to get an increase in speed, you must reduce the FBVR so there will be a much stronger field excitation. When the

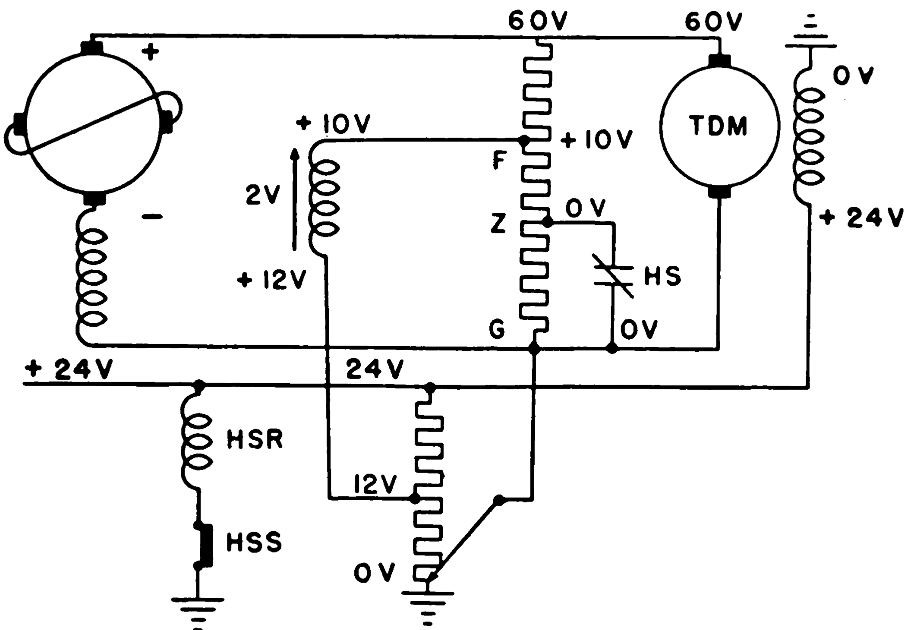

Figure 38.—High speed operation.

high speed switch (button) is closed, a high speed relay coil becomes an electromagnet, closes the high speed contacts AND shorts out part of the FBVR. That's what gets the results you want.

Figure 38 shows how all this happens. The relay contacts close, and the control field current rises until the generator voltage reaches 60 v. Point *Z* is at the same potential as point *G*

(0 v.). When point *F* reaches the value of 10 v., the IR drop across the control field is 2 v. This stabilizes things.

To adjust high speed, you can move the HS contact wire at point *Z*. To INCREASE high speed, move point *Z* (figure 38) TOWARD point *F*. To DECREASE high speed, move point *Z* AWAY FROM point *F*.

Of course, any increase or decrease of FBVR for high speed depends on the normal speed setting. Changes in normal speed adjustments WILL AFFECT high speed adjustments. However, changes in high speed adjustments will NOT affect normal speed.

So always be sure to adjust for normal speed first before attempting to adjust for high speed operations.

When setting the speeds of a turret in elevation, you will have to calculate the speed in degrees per second. This is because the turret does not make a complete revolution in elevation and depression. Speed settings in elevation are not so important as they are in azimuth, since the turret does not have to rotate so far.

Here is a little list of adjustments for best operating speeds —

Azimuth high speed	— 45 degrees per second (8 sec. per rev.)
Azimuth normal speed	— 20 degrees per second (18 sec. per rev.)
Elevation high speed	— 30 degrees per second (12 sec. per rev.)
Elevation normal speed	— 12 degrees per second (30 sec. per rev.)

COMPOUNDING ADJUSTMENTS

The external load on a turret is going to vary, depending pretty much on the force of the slipstream on the turret guns. But if this affects the speed at which a turret will rotate, it's rather disconcerting to the gunner.

As the guns go into the slipstream, an INCREASED LOAD is applied to the turret drive motors. This means that MORE CURRENT must be supplied by the amplidyne generator to keep the turret drive motors at proper speed.

To compensate for the increased load, a larger field flux will be necessary in the amplidyne generator to maintain sufficient voltage. This is taken care of by ADDITIONAL WINDINGS on the series field.

Figure 39 indicates the proportionate amount of windings in the series field, and their purpose. The top and largest portion sets up the flux to oppose the load-axis flux. The middle portion compensates for the voltage drop across the TDM and amplidyne armatures.

These windings are placed on the SERIES FIELD rather than on the control field. This is because you want to keep the control field as small as possible for quick excitation.

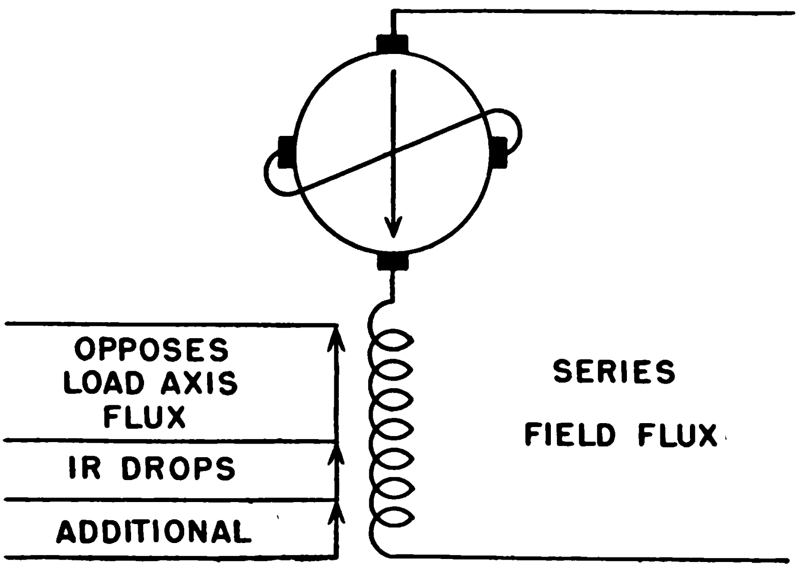

Figure 39.—Windings in series field.

The windings at the bottom are added to make certain that there will be ENOUGH FLUX set up in the amplidyne so that sufficient voltage will be supplied to operate any turret drive motor at the proper speed.

When the series field is too large and the amount of external load on the guns increases, the turret will speed up. This is called an "over-compounded" situation. In figure 40*A*, you'll see a graph indicating the relationship between speed and load. You'll see further that a "flat-compounded" turret will maintain a constant speed under increasing load conditions, and that an "under-compounded" turret will decrease in speed as the external load is increased. It is obvious that FLAT-COMPOUNDING is just what the doctor ordered.

For purposes of controlling this additional flux in the series field, rheostats (variable resistances) are placed in parallel with the series field.

Part *B* of figure 40 shows these rheostats, one for normal speed compounding (NSCR), and one for high speed compounding (HSCR).

Consider normal speed compounding first. The amount of magnetic flux set up by a coil depends upon the ampere-turns ratio. A current flow of 8 amperes is shown in the load circuit,

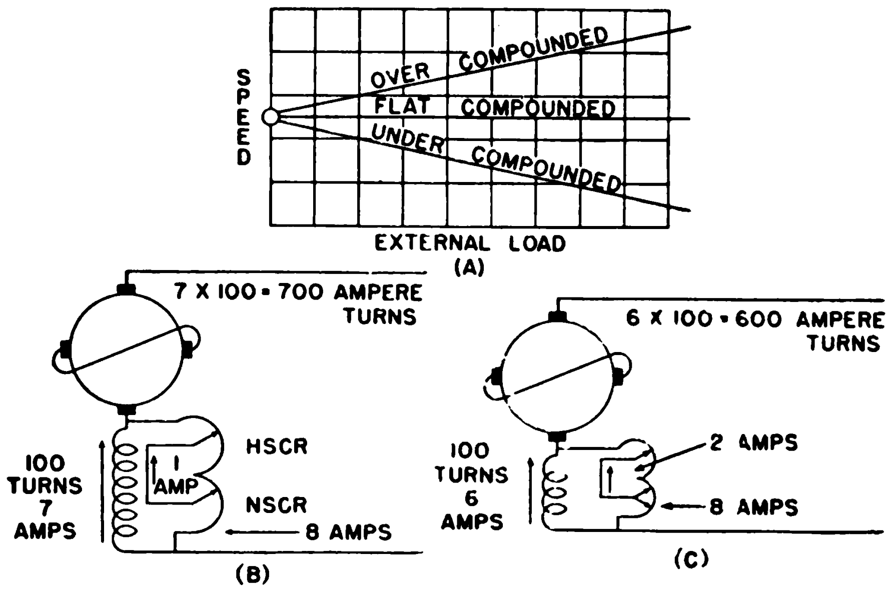

Figure 40.—Compounding.

with 7 amperes going through the series field and one ampere through the resistance. For example, if the series field had 100 turns of wire, there would be 700 ampere-turns (7×100) of flux set up.

If the turret you were adjusting speeded up when an external load was applied to the gun, this would indicate that the series field was too large. In order to decrease the field strength, you must decrease the amount of current flowing through the field. This will decrease the ampere-turns ratio, and therefore the strength of the field.

You may decrease the current flow in the series field by bypassing more of it around the field through the rheostats.

Part *C* of figure 40 shows the amount of normal-speed compounding resistance (NSCR) being decreased, allowing 6 amperes through the field of 2 amperes through the rheostats.

Compounding must be readjusted several times during the life of a turret to compensate for wear of the parts and a consequent decreasing internal resistance of the turret. If an amplidyne is taken from one turret and put on another turret, in all probability it will have to have its compounding rheostats readjusted.

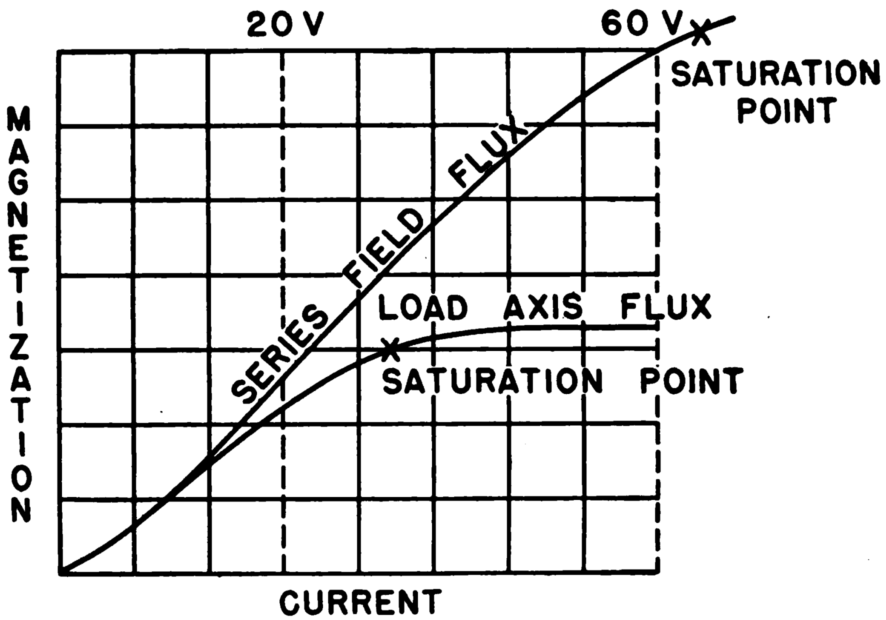

Figure 41.—Effective magnetization curves.

There are two easy rules to observe when adjusting compounding —

To correct an over-compounded turret, decrease resistance in parallel with the series field.

To correct an under-compounded turret, increase the resistance in parallel with the series field.

You are probably wondering why it is necessary to set compounding for high speed, and if once the series field is made in effect equal to the load-axis flux (as in normal speed compounding), why will this setting not be good for high speed? Here's why it won't be.

A turret that is flat-compounded at normal speed will speed up under load when the turret is put in high speed unless you change its compounding for high speed. This happens because the load-axis flux and the series field flux DO NOT INCREASE EQUALLY in the higher speed brackets.

As the turret speed increases, the load current increases. Figure 41 is a graph showing the effective magnetization curves of the load-axis flux and the series-field flux.

As the current increases through the circuit, both fluxes increase along practically the same line up to 20 v. generated output. After 20 v., the load-axis flux increases at a SLOWER RATE than before, but the series-field flux continues to increase at approximately the same rate as before.

Why? Because the load-axis flux is an armature-reactance flux, and it reaches its saturation point before the series-field flux does.

If the series-field flux becomes appreciably greater than the load-axis flux, the result will be over-compounding. This is why the turret may be compounded sufficiently for all the speeds in the normal speed range (0 v. to 20 v.) but must be re-compounded for the high speed range (20 v. to 60 v.).

You remember the rule for correcting an over-compounded turret. It was to DECREASE the resistance in parallel with the series field.

Figure 42 shows a set of high-speed contacts placed so as to short out the lower (NSCR) compounding rheostat when the contacts are closed.

These contacts are on the same relay as the high-speed contacts in the feedback voltage circuit. When the HSS switch is closed, the high speed relay closes both sets of contacts, giving high speed operation and high speed compounding simultaneously. High speed compounding can be adjusted by increasing or decreasing the HSCR resistance.

The rules for correcting normal speed compounding hold true for correcting high speed compounding. But remember always to adjust high speed compounding before normal speed.

You'll find it's a fact that when the turret is flat-compounded, the amplidyne actually is SLIGHTLY OVER-COMPOUNDED. It is important that you understand that there is a definite relationship existing between the FEEDBACK VOLTAGE and COMPOUNDING.

For example, consider a flat-compounded turret operating at normal speed. If the gunner brings the gun from the aft position to a broadside or forward position, the slipstream against the gun creates a relatively heavy load for the TDM. As the load is increased on the TDM, it will tend to decrease in speed and to draw more current, thus causing the series-field flux to become larger.

Since the series-field flux is in the same direction as the control-field flux, the generated output will rise slightly, tend-

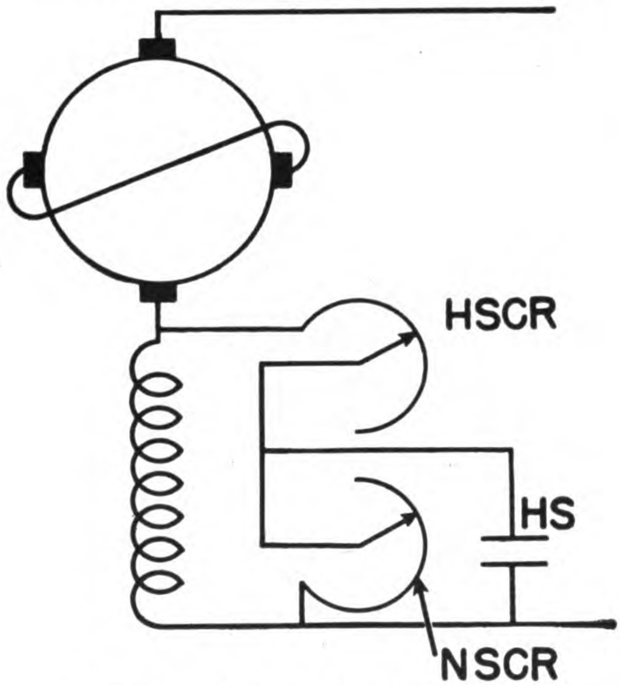

Figure 42.—High-speed contacts.

ing to bring the motor back up to speed. As the generated output rises, the voltage drop across "FG" in the feedback voltage circuit becomes greater. This causes the control-field flux to be decreased slightly, allowing a new stable condition to be established, allowing the turret to remain at a constant speed.

If EITHER ONE of these relationships is destroyed, your turret goes sour.

FURTHER CHECKS

Since this relationship exists between compounding and FBVR, after adjusting either one, be sure to check the other and make any necessary adjustments. There is no rigid procedure as to which should be adjusted first, but it is important to remember that the compounding adjustments should be about right before the final speed adjustments are made.

The true test for compounding is IN THE AIR under flight conditions, but it has been learned from experience that a turret that is compounded on the ground will be properly compounded under flight conditions.

When compounding the turret, it is NOT RECOMMENDED that the gun be used to push the turret around. This will tend to destroy the harmonization of the gun and the sight. Use some part of the frame or armor plate to hold on to when applying the load.

High speed compounding must be adjusted before normal speed compounding, because the adjustment you make for normal speed compounding depends upon the amount of resistance being used in the HIGH SPEED compounding rheostat. It is obvious that if high speed compounding is changed, normal speed compounding must be readjusted.

On the new standard amplidyne (G.E. Model 5AM31-NJ18A), such as are used on the Grumman "B" (150 SE–2) turret, the compounding rheostats are located on the amplidyne. A ⅝-inch open-end wrench and a small screwdriver are the only tools needed to adjust compounding. That's all, plus your knowledge of how to use them.

A-HUNTING WE WON'T GO

Hunting for enemy aircraft is the kind of hunting a turret gunner really goes for. But there's another kind of hunting that you will want to AVOID. This "hunting" is a type of oscillation which often develops in a turret.

As a matter of fact, the turret system you've followed through so far is actually too sensitive to control properly. The amplidyne output changes too rapidly, and this is likely to cause the TDM to oscillate or HUNT.

This is where you call on the anti-hunt circuit to declare a closed season on this type of hunting.

Consider a turret operating at half normal speed along line

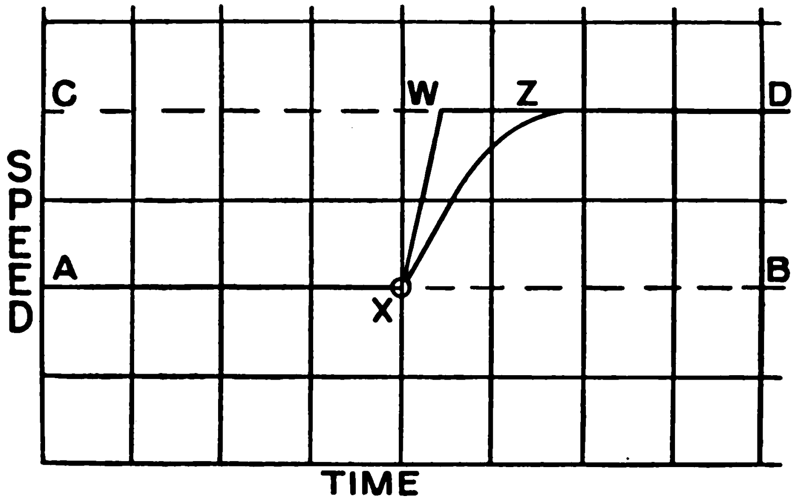

Figure 43.—Time, speed graph.

AB in figure 43. If the gunner wishes to reach full normal speed rapidly, he quickly deflects the potentiometer pointer, and because of the quick response characteristic of the amplidyne, he immediately is rotating at full normal speed along line *CD*.

Curve *XW* in figure 43 indicates that there will be practically no time interval for the change of speed. This sounds good, but it isn't. Because acceleration will be JERKY. This will definitely cause hunting under certain conditions.

The desirable acceleration curve is more like that of *XZ*.

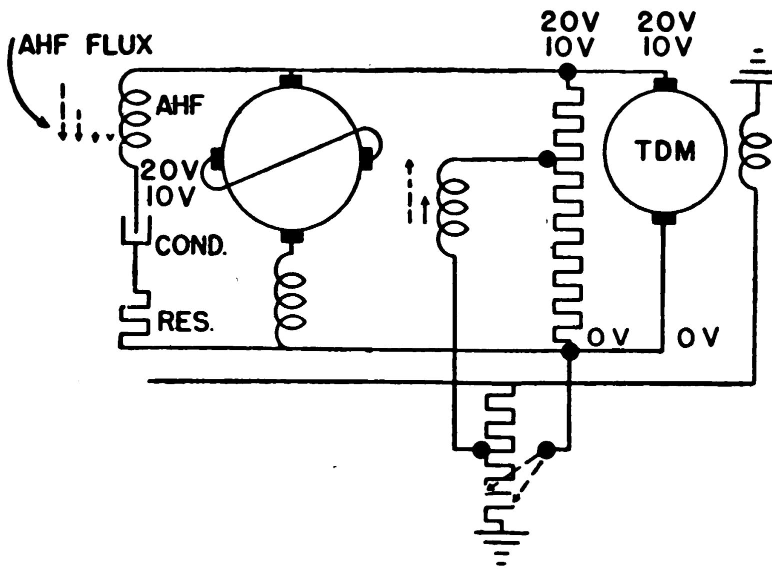

Figure 44.—Anti-hunt field in circuit.

This shows the speed increasing more slowly, and easing into full high speed. Notice that the time required is somewhat longer, though it must be understood that this time element is only a fraction of a second.

In order to provide slower acceleration without changing the other desirable characteristics of the system, such as the feedback voltage circuit, the anti-hunt circuit was added to the system.

In figure 43, the anti-hunt field (AHF), a condenser, and a resistor have been hooked in series across the output of the amplidyne. The AHF is wound on the bottom pole piece of the amplidyne, together with half of the series field. Its action is to oppose any change of the control-field flux.

With the potentiometer at half deflection, the generated output is 10 v. There is no flow of current in the AHF because of the condenser which has charged to the value of the generated (10 v.) output.

If the potentiometer pointer is moved suddenly to full deflection (dotted line), the control field tends to rise quickly and the generated output does likewise. As the generated output builds up to 20 v., the condenser begins charging to 20 v. also. The condenser will always charge or discharge to whatever the generated voltage value is.

As the condenser charges to 20 v., a small, gradually diminishing current will flow in the anti-hunt circuit until the condenser becomes fully charged. When the condenser is charged to generated output value, there will be NO CURRENT FLOW in the anti-hunt circuit.

Thus, you see that if the current flow rises quickly, and then drops gradually to zero, the magnetic flux it sets up in the AHF will do so, too.

Figure 45 is a vector diagram of figure 44. The solid, black arrow represents the control-field flux at half potentiometer deflection. When the potentiometer is suddenly deflected, the control-field flux builds to a MAXIMUM almost immediately. This is represented by the arrows pointing upward.

When this maximum build-up occurs, generated output tries to increase IMMEDIATELY to 20 v. But this action is slowed down because the condenser begins to charge.

Now what? This permits a current flow through the AHF, and a flux is set up in opposition to the control-field flux.

This results in a gradually increasing "effective" control-field flux, like "OP," which allows the generated output to

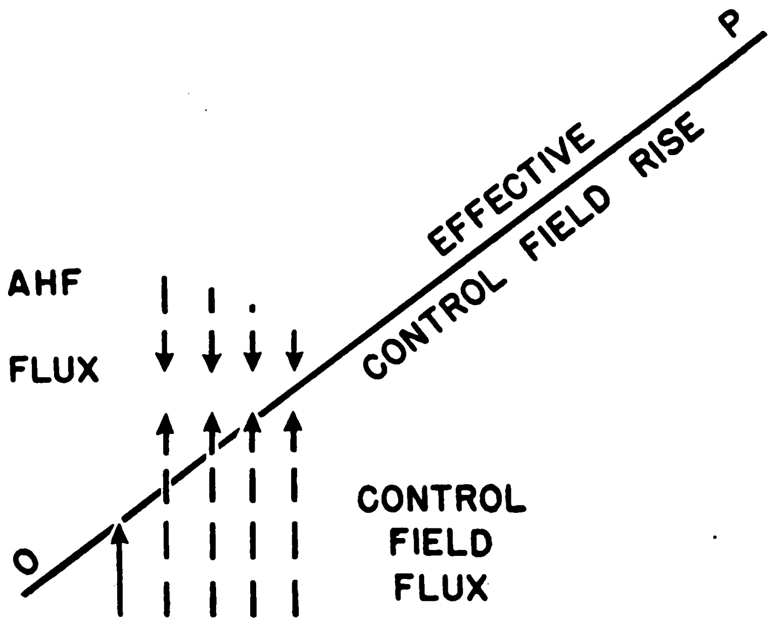

Figure 45.—Vector diagram of figure 44.

increase GRADUALLY. And therefore, the speed of the turret increases GRADUALLY. Which is what you and the anti-hunt circuit are working for.

This circuit also slows the response when turret speed is to be decreased. Incidentally, remember that when you say

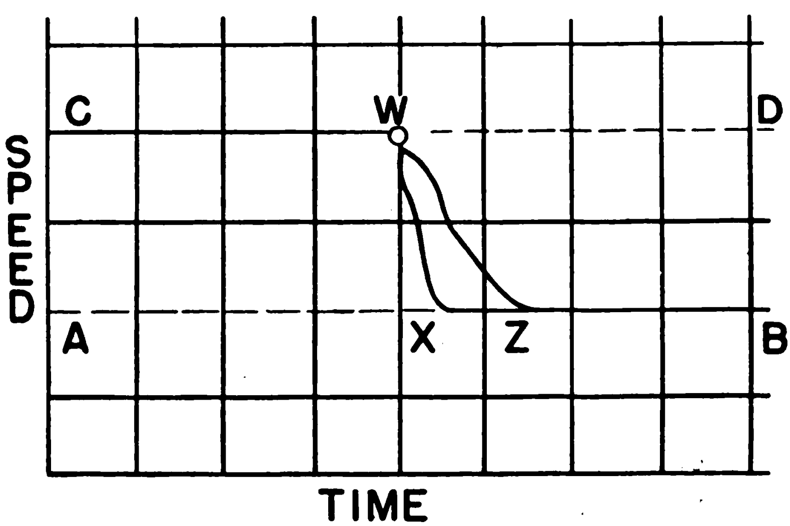

Figure 46.—Time, speed graph.

"slows," you're still talking in terms of SPLIT SECONDS, in this case. You're not out to slow that turret down to a walk, by any means, but you don't want such sensitive controls that the turret becomes hard to handle.

Take a look at figure 46. The turret is operating at normal speed along line *CD*. If the potentiometer pointer is suddenly moved to half deflection, the turret speed will DECREASE, operating along line *AB*. Without the anti-hunt field, you'd get a

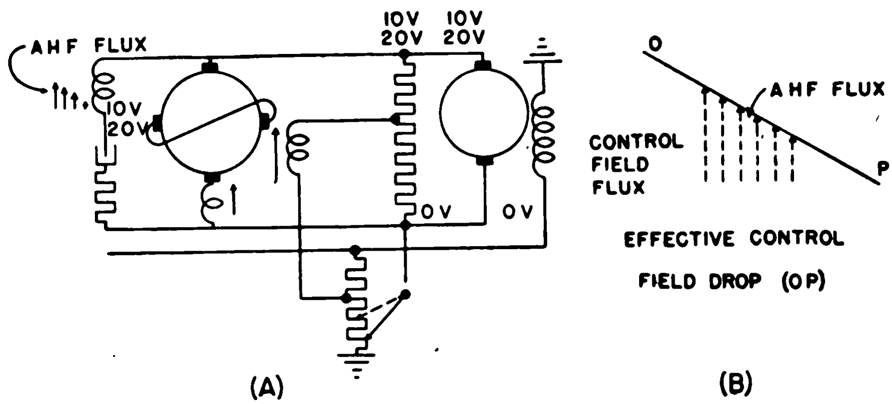

Figure 47.—Sudden deflection of potentiometer.

sharp decrease in speed, like the one shown in curve *WX*. And once again, you'd get what you don't want — jerky, hunting response.

Curve *WX* shows how the slower decrease in speed is produced when the AHF circuit puts on the brakes for you.

SLOWING THE DECREASE

Now you will want to follow how the AHF smooths over the effect of decreasing the speed of the turret drive. Figure 47*A* shows the potentiometer at full deflection and the control field (solid arrow) at its maximum value. This allows a generated voltage of 20 v. and consequently, the condenser is charged to this voltage.

Now what happens when the potentiometer is moved suddenly to half deflection? The generated voltage drops to 10 v., but it is prevented from dropping too suddenly because of the flux set up in the AHF field.

The condenser begins to discharge rapidly at first, and then more slowly as it approaches 10 v. This sends the current through the AHF which sets up the flux.

Figure *47B* is a vector diagram showing the control-field flux dropping immediately to half value. However, the AHF flux adds to it, resulting in a gradual weakening of the "effective" control field flux.

All this gets the results you are after — the cause the generated output, and therefore the decreasing speed of the turret, to slow down at a smoother rate.

That's the anti-hunt field's one definite purpose. It acts as a shock absorber for any change in generated voltage.

As you've learned, it does this in TWO WAYS —

By opposing the building-up of the control field.

By opposing the breaking-down of the control field.

That's the anti-hunt circuit.

SHORT CUT TO COMPOUNDING

Now that you're familiar with the anti-hunt circuit, you can make use of a short cut method of compounding.

This method utilizes the fact that an over-compounded turret has a tendency to hunt, because the anti-hunt field is not strong enough to compensate for this additional series, field flux. Here's how the method works.

First, make sure the turret is out of gear. Then you disconnect your AH field.

Next, start the amplidyne (either one). Close the action switch with full deflection on the potentiometer. Now close the high speed switch. You will remember that you always compound for high speed BEFORE normal speed.

Now move the compounding rheostat to increase resistance. When the TDM begins to hunt (vibrate), STOP. Now move the rheostat back to the point where the hunting stops.

This gives you correct FLAT-COMPOUNDING. Isn't it simple?

Repeat this procedure, closing the normal speed switch, to compound for normal speed.

This SHORT CUT method of compounding is handy to use in connection with turret trouble shooting procedure. Later on, when you come to take up the individual electric turrets, you'll get into this important topic of TROUBLE SHOOTING. And when your trouble shooting calls for adjusting for compounding, remember that you can use this faster, short cut method.

Of course, you can use the other, longer method, too, of applying a load to the turret. In fact, this is probably the only method you'll find in the various turret manuals produced by the manufacturers.

But the short cut method WORKS. Don't be afraid of it!

LOOKING FOR TROUBLE

Figure 48 is a simple schematic diagram of a typical electrical turret system. You can see that it has a potentiometer, an

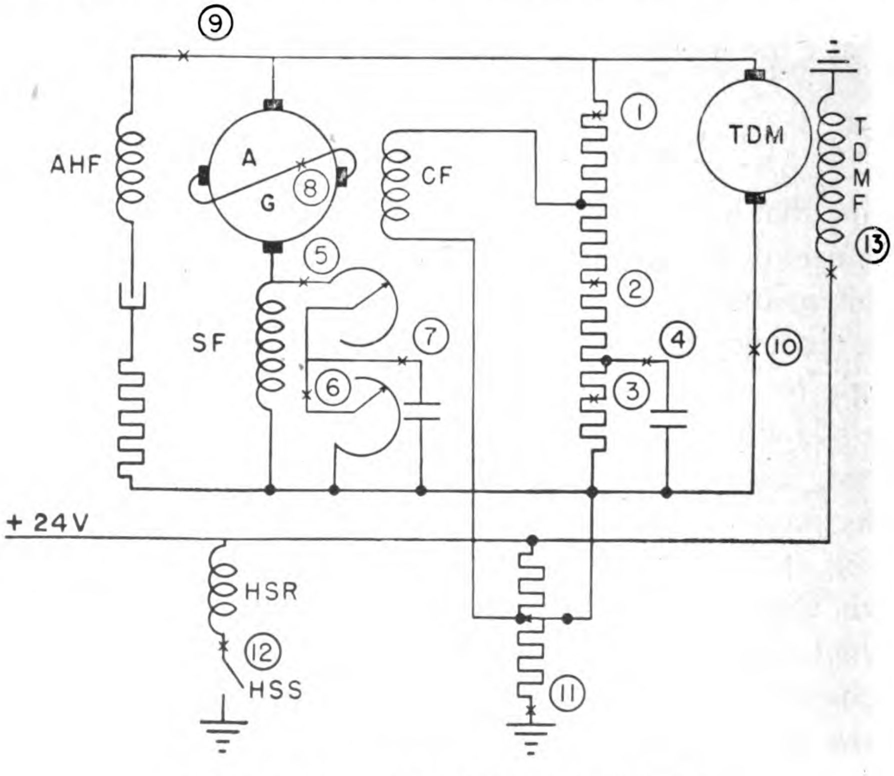

Figure 48.—Schematic of typical turret.

amplidyne, a turret drive motor, a feedback voltage circuit, a high-speed circuit, a compounding circuit, and an anti-hunt circuit.

In short, it has everything discussed in this chapter.

By studying this diagram, you can see how all the individual units are tied together, and how they are interrelated to form the complete electric turret system. Remember that all amplidyne-controlled electric turrets operate on principles based upon this same fundamental schematic. Later, in your study of the various individual makes of electric turrets, you'll see how true this is.

The only thing that makes one electric turret different from another one is that each manufacturer has added refinements in the form of additional circuits so that his particular turret will perform special functions for the airplane for which it was designed.

In figure 48, if *X* denotes a break or opening in wiring in the electrical schematic, see if you can determine how each break, designated by an encircled number, will affect the turret and why it will do so.

Then make a check on the explanations that follow and see how close you come to analyzing the troubles.

What happens in BREAK NO. 1? Your turret will run faster in both normal and high speeds.

WHY? This is a break in the feedback voltage circuit above the control field tap. Therefore, the resistance in series with the control field has no feedback voltage value. The ohmic resistance value is less than the feedback voltage value. With less effective resistance in the control field circuit, more current will flow. This additional current flow causes more flux to be set up in the control field for any given potentiometer deflection. Consequently, the generated output and turret speed will be greater.

What happens in BREAK NO. 2? Now your turret will run slow at normal speed and not at all at high speed operation.

WHY? This break in the feedback voltage circuit cuts the continuity of the usual control field circuit. With this break, the control field current must find another path back to the potentiometer. The path it takes is up through the top part of the feedback resistance, through the TDM, and back to the potentiometer. Enroute, it encounters generated voltage, resistance, and the CEMF of the TDM. These resistances allow a relatively small current flow in the control field. Therefore, it will be under-compounded.

What happens in BREAK NO. 3? The turret will run very slowly at normal speed, but OK at high speed.

WHY? At normal speed, you notice that the turret runs slowly for the same reason as in the case of the No. 2 break. When the HSS is closed, the contact in the speed circuit bypasses current around the break. The HS control field circuit is not affected, and the turret will operate at the correct high speed. Compounding is not affected, however.

What happens in BREAK NO. 4? The turret will not operate at high speed.

WHY? The HS contact wire in the feedback voltage circuit is broken, so no feedback voltage resistance is cut out to allow more current to flow in the control field circuit. High speed operation will be the same as normal speed, except that the HS contact for compounding causes the turret to be under-compounded when the HSS is closed.

What happens in BREAK NO. 5? You see that the turret speeds up under load in both normal and high speeds. Vigorous hunting also will result.

WHY? Turret will be over-compounded in both normal and high speeds because the continuity of the compounding rheostat circuit has been broken. If the turret is over-compounded to any extent, it has a tendency to hunt, as you remember. In this instance, it is at maximum over-compounding.

What happens in BREAK NO. 6? The turret is over-compounded at normal speed.

WHY? Compounding circuit is open for normal speed operation. High speed compounding won't affect operation, however, because the HS relay contact bypasses current around the break.

What happens in BREAK NO. 7? Now it's over-compounded at high speed.

WHY? When the HS contacts in the compounding circuit are closed, there is no continuity in the HS compounding circuit. This causes the turret to use normal speed compounding for both normal and high speeds.

What happens in BREAK NO. 8? Turret runs at very slow, sluggish speed.

WHY? If the short circuit wire is broken, there can be no short-circuit-axis flux. But the load brushes are able to pick off a low generated voltage from the control field excitation even though they are not in the proper plane of commutation. This will result in very low speed operation.

What happens in BREAK NO. 9? Turret will hunt, if slightly over-compounded. Changes in speed will be jerky and uneven.

WHY? Turret will be overly sensitive to control, because the control field builds up too quickly. The feedback circuit provides sufficient control to prevent hunting if the turret is flat-compounded.

What happens in BREAK NO. 10? You have generated output, but no operation.

WHY? The control field and feedback circuits are intact. Therefore, there will be a generated voltage at potentiometer deflection. TDM cannot move for its armature receives no power.

What happens in BREAK NO. 11? Your turret won't operate.

WHY? The potentiometer is useless, unless there is a current flow through it. All of the potentiometer above the break has a potential of 24 v. with respect to ground, so no difference in potential can be used to send current through the control field.

What happens in BREAK NO. 12? You have no high speed operation.

WHY? It is impossible to energize the high speed relay, therefore the HS relay contacts in the feedback and compounding circuits cannot be closed.

What happens in BREAK NO. 13? You hear the amplidyne howl when the potentiometer is deflected, and the turret does not move unless you give it a push. Regardless of the direction of potentiometer deflection, the turret will run abnormally fast in the direction pushed. You have speed control, but no directional control.

WHY? When the potentiometer is deflected, the amplidyne sends current to the TDM. The TDM tries to move, but can't develop enough torque because it has no field excitation except for residual magnetism. When the field on this type of motor is decreased, the speed of rotation is increased, but the amount of torque it develops decreases.

The amplidyne will howl because it is overloaded in putting

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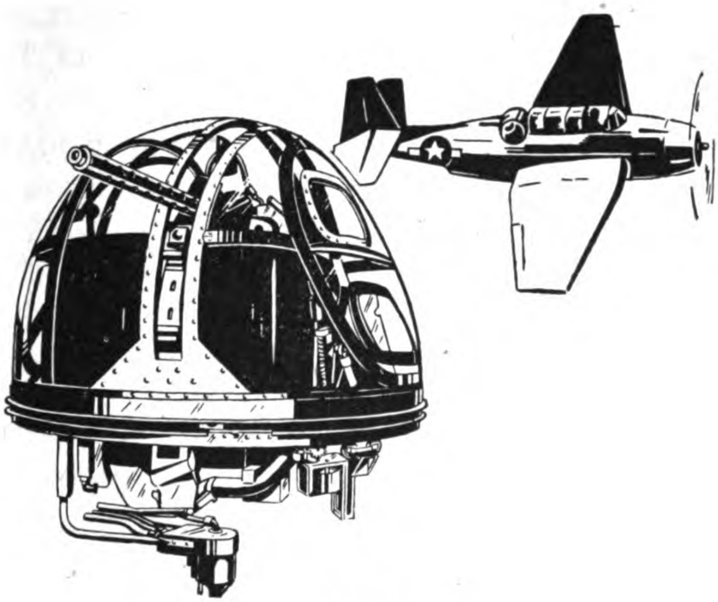
out a high current through the TDM armature. This occurs because the TDM is not rotating, therefore there is no counter-electromotive force, and the armature resistance of the TDM is only approximately .2 ohms.

As soon as the turret is pushed, starting friction is overcome, and the turret will rotate rapidly. Speed can be controlled and the turret will stop when the potentiometer pointer is brought to neutral.



CHAPTER 3

GRUMMAN 150 SE–2 TURRET

THE AVENGER'S STING

A TBF is making a run at 300 feet. Two thousand yards from an enemy cruiser, its fish splashes into the water and speeds toward the target.

And, if there are hostile aircraft around, right here is where a big headache can develop. A torpedo plane must make its attack at low altitude. Getting back to the carrier sometimes means FIGHTING back.

That's where the Grumman 150 SE–2 turret — and its gunner — have a chance to PROVE THEIR WORTH. And they have, in HUNDREDS of combat missions.

Yes, the Grumman turret has proved itself to be a durable, reliable, and often indispensable piece of equipment on the TBF or TBM.

It mounts a single .50 caliber. But that's enough to do the job if the bursts land where you want them to land.

WHAT MAKES IT CLICK?

The Grumman is a ball turret — one in which you ride with the turret in both train and elevation.

A 24-28 v. d.c. system powers both the vertical (elevation and depression) and train (azimuth) motion of the turret. The vertical range of 115 degrees includes the 85 degrees can't develop enough torque because it has no field excitation. elevation above the horizontal and 30 degrees below the horizontal. The train motion is 360 degrees, either clockwise or counterclockwise.

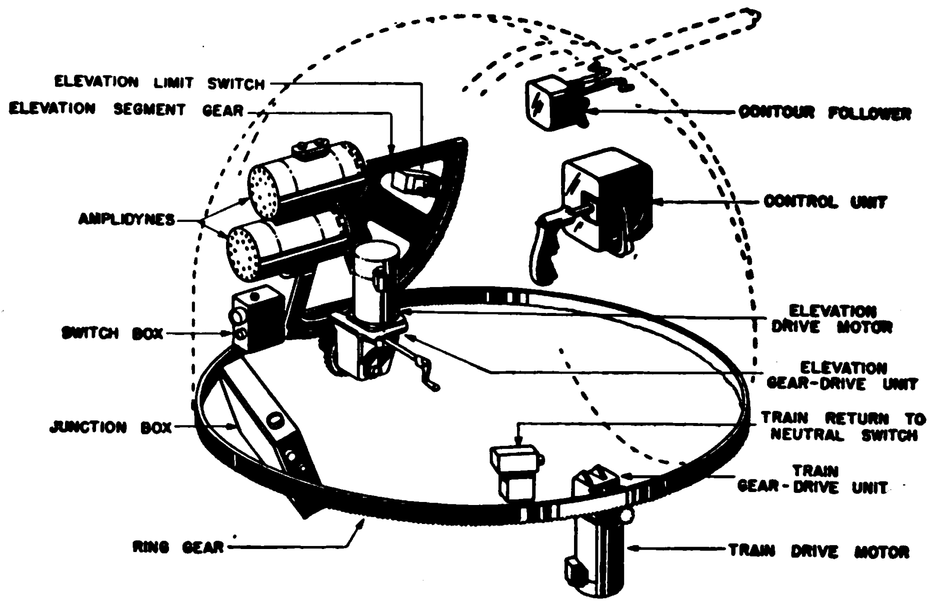


Figure 49.—Units making up Grumman 150 SE–2 turret.

The turret drive consists of these parts —

1 control unit,
1 train drive unit,
1 elevation drive unit,
1 elevation upper limit switch,
1 elevation return to neutral switch,
1 train return to neutral switch,
1 contour follower switch unit,
1 junction box,
2 amplidyne motor generator units,
1 slip ring unit,
1 elevation gear segment or quadrant, and
1 azimuth or train ring gear.

Analyze each part individually. Figure 49 shows you where all these units are located. You can refer to it as you take up each part.

The CONTROL UNIT, operated by a control handle, completely controls all electric motion of the turret and the firing of the gun. It is shown in figure 50.

The master switch is on the left side of the controller box. When the master switch points up, the switch is ON.

The action switch, located on the control grip, must be closed before the potentiometers are energized and before the turret can be operated. When you release this switch, the turret will AUTOMATICALLY return to stowing position with the gun pointing aft and parallel to the longitudinal axis of the ship.

The turret will return to neutral in train by the shortest path and remain there while the gun returns to neutral in elevation.

On the control handle there's a high speed switch, the gun firing trigger switch, and the action switch. At the right and bottom side of the controller box is a latch which, when released, permits you to tilt the controller box up to allow room for entering and leaving the turret.

When the control handle is moved to the right, the turret will turn counterclockwise in train, and when the control handle is moved to the left, the turret will turn clockwise in train. Simple enough.

When the control handle is depressed from the neutral position, the gun will move upward, and when it is elevated from neutral position, the gun will move downward. By moving the control handle diagonally, you can get simultaneous train and elevation movement.

The speed of both train and elevation or depression movements is proportional to the deflection of the control handle from neutral position. The equipment is so designed that a minimum velocity of a half degree per second in either train or elevation can be maintained. Normal elevation speed is approximately 12 degrees per second, and normal train speed is 20 degrees per second.

By closing the high speed switch, you cut out a portion of the feedback voltage resistors, thus giving an increased range of speed. You can get approximately 30 degrees per second for elevation, and 45 degrees per second for train operation.

Operation of the control handle actuates two sliding pointers (contacts) on two potentiometers. One is for the TRAIN AMPLIDYNE and one for the ELEVATION AMPLIDYNE. The potentiometers are center tapped, thereby making it possible to reverse the polarity of the generator output by reversing the control field polarity. The generator output is controlled by varying the generator control field excitation. All of this is accomplished through the DIRECTION and the AMOUNT OF DEFLECTION of the control handle.

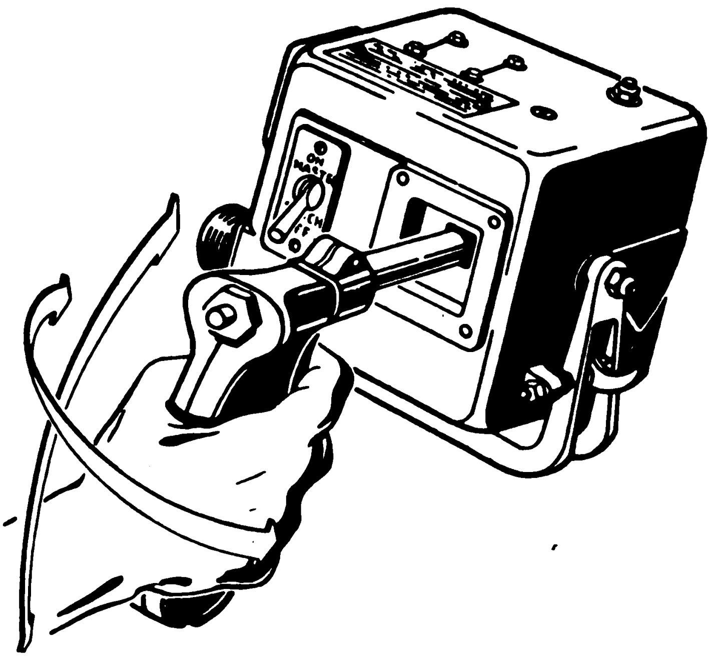


Figure 50.—Control-grip movements (schematic).

The train and elevation turret drive motors are directly connected to their respective amplidyne units, so their speed and direction of rotation is controlled by the polarity and size of the output of each respective amplidyne.

The TRAIN DRIVE UNIT is located on the gunner's right and directly below the right trunnion end-frame. It consists of an electric motor, gear box, and hand clutch. It is geared directly to the azimuth ring gear, which is secured to the track and train unit.

What's it for? You know the answer. The purpose of this unit is to drive the turret in train operation. The schematic of this unit appears in figure 51.

The purpose of this unit is to drive the turret in elevation and depression operation, as you know.

The unit is geared directly to the elevation gear quadrant, which is stationary and secured to the left trunnion end-frame.

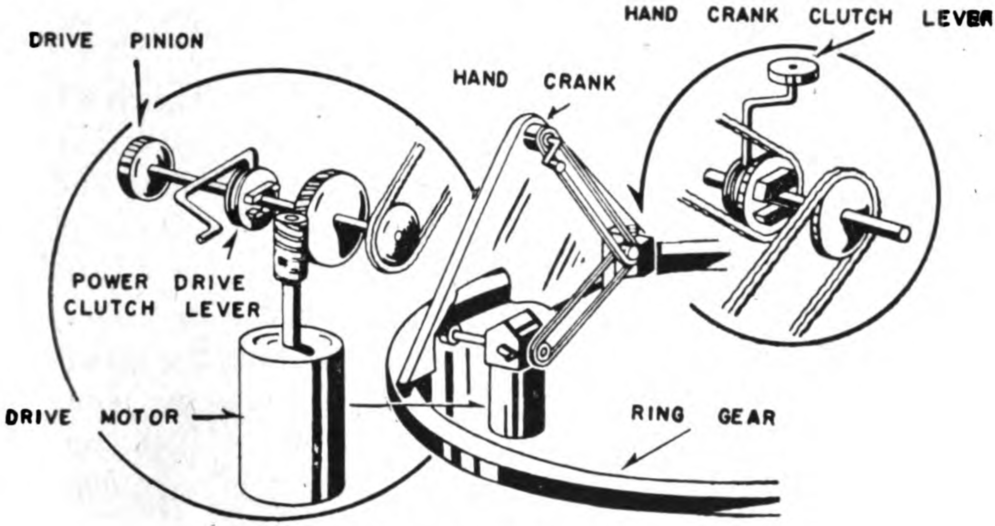


Figure 51.—Train drive (schematic).

The TURRET ELEVATION DRIVE UNIT is located on the gunner's left between the ammunition box and the elevation gear quadrant. It consists of an electric motor, hand clutch, and gear box. Take a look at the schematic in figure 52.

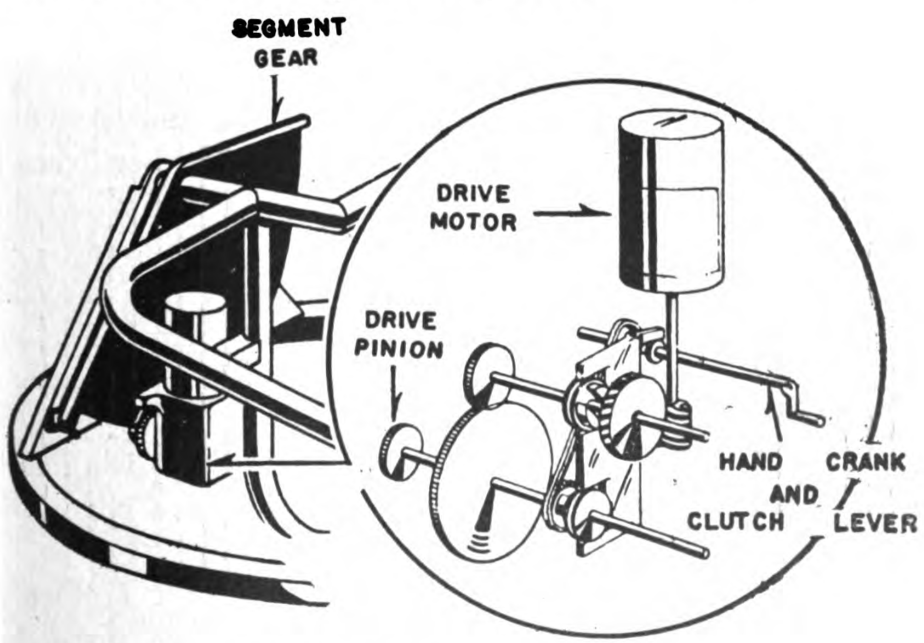


Figure 52.—Elevation drive (schematic).

Now a word of caution — DO NOT ENGAGE GEARS WHEN TURRET DRIVE MOTORS ARE RUNNING IN EITHER TRAIN OR ELEVATION.

Both elevation and train drive motors are equipped with a distinctive feature — a BRAKE SOLENOID, which stops the turret immediately after the current is shut off.

The ELEVATION UPPER LIMIT SWITCH is a micro-switch which is housed in a switch box in conjunction with another micro-switch. It is secured to the left trunnion end-frame, and is operated by a cam which is fastened to the equipment plate between the amplidyne units and the elevation gear quadrant.

As the gun nears the zenith point or maximum elevation, the upper limit switch is actuated by the cam striking the actuating roller of the switch plunger. The cam depresses the plunger, which closes the switch, thereby energizing the RNDR (return to neutral in depression relay). This places a reverse potential on the control field, and the gun depresses. The gun will only depress far enough to allow the micro-switch to open again by rolling off the cam. If you are holding the control handle in a depressed position, the gun will be elevated again, and the sequence will be repeated.

The TRAIN RETURN TO NEUTRAL SWITCH (TRNS), and the DEPRESSION RETURN TO NEUTRAL SWITCH (DRNS) accomplish the automatic return of the turret and gun to neutral or stowing position.

The TRNS is located on the gunner's right, and is secured to the U-channel ring. This unit includes two micro-switches in one housing. They, in turn, are operated by a cam wheel that is rotated by four pins secured in the track-and-train unit. The inside switch is the "B" switch, which governs the direction of rotation in which the turret will return to neutral. The outside, or "A" switch, determines when the RNT (return to neutral in train) circuit is closed or opened.

The DRNS (depression return to neutral switch) is a micro-switch on the left trunnion end-frame, in the same box as the elevation upper limit switch.

On the release of the action switch, the RNTR (return to neutral in train relay) is energized, provided the turret has been moved out of stowing position. When the RNTR is energized, the control of the turret is automatically removed from the gunner, and the turret will return to stowing position in train. The direction of return (clockwise or counterclockwise) will be dependent upon the position of the "B" switch. The turret will return by the SHORTEST PATH to the stowing position.

As the turret moves into stow in train, the cam wheel is rotated by the RN pin. The DRNR (depression return to neutral relay) is energized through the DRNS, and the gun is returned to neutral in depression. As the gun nears the hori-

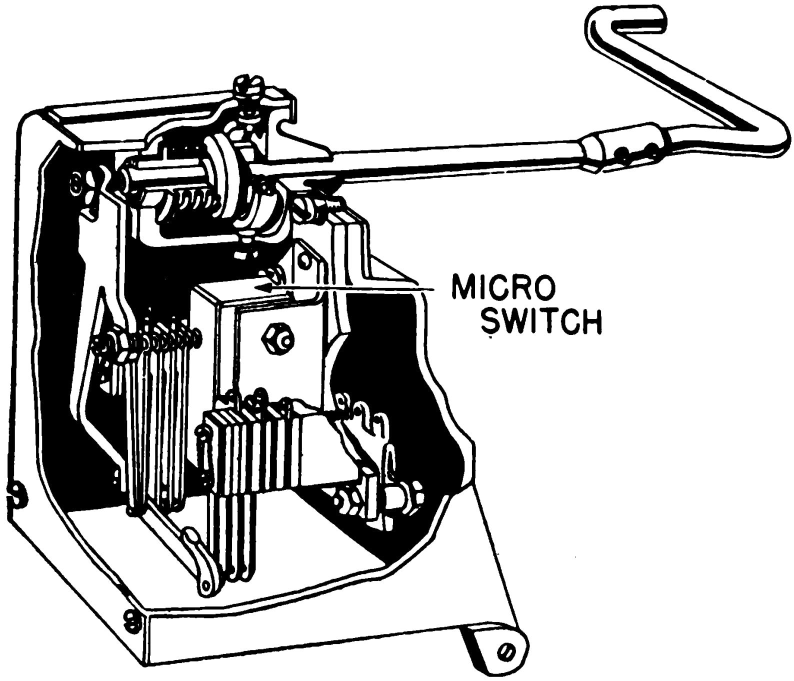


Figure 53.—Contour follower (cutaway).

zontal position, the DRNS is opened by the cam, the electrical system is opened, and power to the amplidyne units is cut off.

The CONTOUR FOLLOWER is your SAVE THE FUSELAGE assistant.

The contour follower is mounted under the barrel of the gun. To see what it looks like, refer to figure 53.

The box contains a two-position micro-switch, six pairs of contacts, and two resistors (12 ohms and 25 ohms). There are two pivoted arms projecting through the gun slot in the turret dome, which ride against the contour rail.

When these arms strike the rail, they actuate the various switches in the contour follower box. The only function of the contour follower is to prevent the gun from striking any part of the fuselage. It has no connection with the profile interrupter circuit.

The JUNCTION BOX is mounted on the rear of the seat, and incorporates four relays, five resistors, two condensers, and necessary wiring. Also located around three sides are seven disconnect plugs.

You'll find the SWITCH BOX located on the gunner's left, shoulder high. It has nine cables leading off, and houses both amplidyne switches, trouble light switch, gun reset, and six condensers for the amplidyne drive motors. These condensers prevent radio interference set up by commutation.

As you know by now, the AMPLIDYNE MOTOR-GENERATOR UNITS (MODEL # 5AM31NJ18A) are really the HEART of the turret drive. They are horizontally mounted on the gunner's left between the left trunnion end-frame and the expended clip and shell box. The upper unit is the elevation unit, and the lower one is the azimuth or train unit. There is one flexible cable leading to each of these amplidyne units. Each amplidyne, you will find, has two variable compounding rheostats mounted on it.

The SLIP RING UNIT is placed directly under the turret, and it is secured to the deck. It is rotated by an L-shaped drive arm.

The slip ring includes two metal cases which house the internal mechanisms. The top half of the ring is free to rotate, while the bottom half is stationary. It contains 10 rings, 10 brush holders, a swivel joint for oxygen, and ground friction plates. There are two disconnect plugs on the upper half of the unit, and three on the lower half. These plugs are for interphone, radio, and power connections.

The FIRE INTERRUPTOR SWITCH ASSEMBLY is actuated by cams which are made to follow the shape of the surfaces to be protected from your gunfire (in other words, the tails, fins, and wing tips of your airplane). The cams are machined on a rotating cylinder, which moves as the turret moves. When the turret moves to a point where the gun would fire into a portion of the plane, the cams on the cylinder press against the fire interrupter switches. This instantly shuts off the fire of the gun until the turret moves on past the "danger zone."

HELPING THE GUNNER

When you come right down to it, the turret is just a gun mount — a device designed to help the gunner do a better job.

So this is where you can learn about the armament characteristics of the Grumman turret. As you already know, there is one .50 caliber M-2 BROWNING MACHINE GUN. To supply this gun, you have provisions for carrying 200 rounds of ammunition in an AMMUNITION BOX located just below the gun.

The FEED CHUTE on the left side of the gun has a built-in "no-return" ratchet which prevents a belt of ammunition from falling back into the chute.

Then there is an EJECTED LINK AND CASE CONTAINER. This will hold 200 links and empty cases, and it is mounted just below the gun. You can pull out a lever mounted at the forward base of the container to open an ejection door so you can dump out the contents into a bag underneath.

A Mark 9 illuminated GUN SIGHT is standard equipment with the Grumman turret. It's mounted on a bracket forward and left of where the gunner sits.

You can locate these various armament units on the X-ray view of the Grumman turret shown in figure 54. You can't miss the machine gun in the upper left of the picture. You can also see the ammunition box, feed chute, and ejected link and case container. The Mark 9 gun sight is a gadget that looks like a little rural mail box, located just to the right of the ejected link container. Note that there is a ring sight mounted up in the back of the bullet-resistant glass shield. This auxiliary sight is to be used in case the Mark 9 gives out.

If you study this cutaway view a little, you can get a pretty good idea of just where the various parts you have learned about are located. This also shows the mechanical features of the turrret.

MECHANICAL FEATURES

In addition to the various electrical devices which make up the Grumman turret, there are important mechanical features. Here are some you'll want to know about.

There's the MOUNTING RING, a special ring which forms an integral part of the TBF's structure, parallel to the aircraft's longitudinal axis.

And there's the TRACK AND TRAIN UNIT, which consists of a two-piece steel ring, upon which there are two machined tracks. The weight of the turret is carried on the upper track, and the turret is stabilized by the lower track. There are 44 holes for

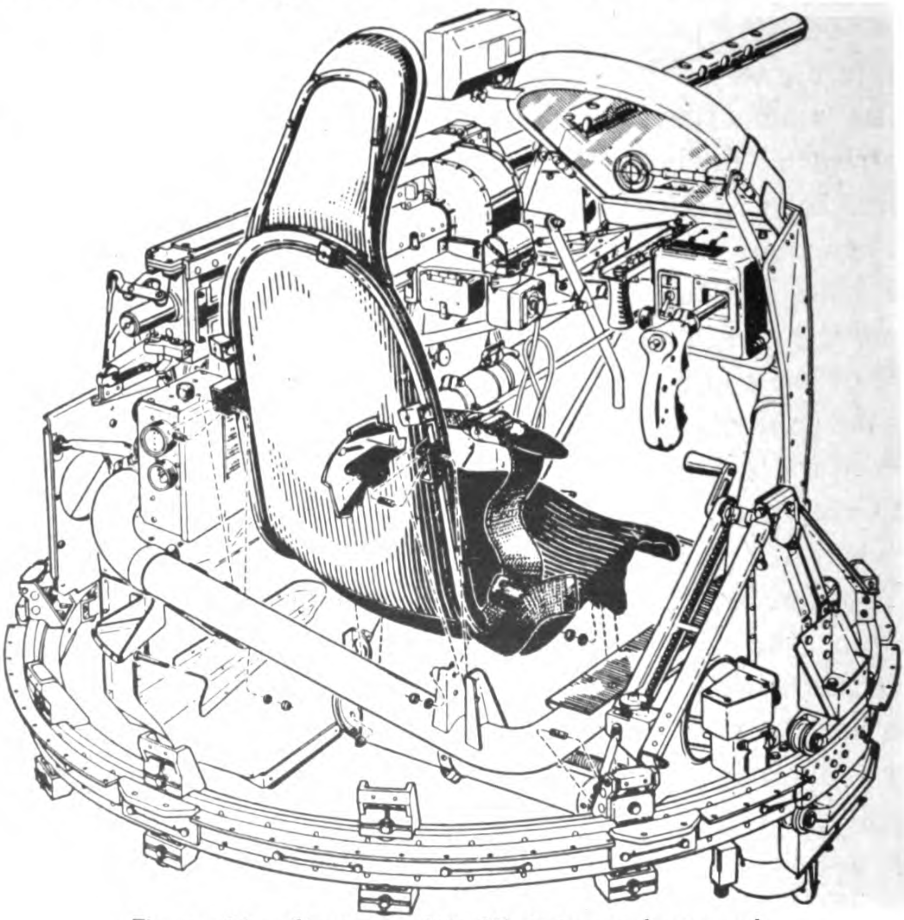


Figure 54.—Grumman 150 SE–2 turret (cutaway).

mounting the azimuth ring gear and 4 holes for mounting the return-to-neutral track pins.

Another mechanical feature is the TRACK SPLICES located at an angle of 180 degrees to each other. They couple the two pieces of steel of track-and-train unit.

The TRAIN RING GEAR is a one-piece steel ring with 44 holes for mounting to the track and train unit. Machined into the bottom side of the steel ring are the teeth for driving the turret in train.

The U-CHANNEL RING OR SADDLE is a circular steel ring located just inside the azimuth track and train unit. The trunnion end-frames and the load and stabilizing roller brackets are mounted upon this U-channel ring.

There are 14 LOAD ROLLERS mounted to the U-channel ring. These rollers take the weight of the turret frame unit and are provided with flanges which guide the turret on the upper track of the track and train unit. They are adjusted by shims at the roller support bracket.

The 14 STABILIZING ROLLERS mounted directly under the load rollers ride against the lower track of the track and train unit. Like the load rollers, these stabilizers are flanged. They eliminate any jump or vibration of the turret when in operation and act as load rollers when the airplane is in an inverted position.

TRUNNION END-FRAMES, structural members bolted to the U-channel unit, are located on the right and left side of the turret. It is through these trunnion end-frames that the turret frame is supported.

Still another mechanical feature of the Grumman turret is the ARMOR PROTECTION. This consists of a ⅝-inch steel plate in front of the gunner, a ⅜-inch plate on each side of him, and a ¼-inch plate hinged to the bottom of the seat.

The ELEVATION GEAR QUADRANT is a spur gear located on the left side of the turret, mounted to the trunnion end-frame. It is provided with two mechanical stops, one at each end of the gear quadrant. These stops prevent the drive gear from running off the gear quadrant when operated manually. A torque arm bolted to the U-channel unit provides additional support to the elevation gear quadrant.

There is a FOOT REST welded to the ⅝-inch armor plate. CAUTION—When operating the turret, be sure to keep your shoe heels ABOVE the rest! They might catch on the circular channel ring when the guns are elevated or depressed, and that wouldn't help your feet a bit.

The two eye-bolt HOISTING LUGS help fasten the gun mount to the turret. They provide a means of hoisting the turret into and out of the aircraft.

LOOK AT THE AUXILIARIES

Now that you have learned the operation of the basic amplidyne system, you are ready to tackle the AUXILIARY CIRCUITS. These supplement the amplidyne system to allow the Grumman turret to do a smooth job.

After going through the operation and purposes of these auxiliary circuits, you will come to a discussion of the correct trouble shooting procedure for each one of them.

For simplicity, you'll find it handy to use ABBREVIATIONS for the various turret parts and actions. Here is a list of common terms, with their abbreviations. They will be used in the rest of this chapter.

HSS	High speed switch.
RNT	Return to neutral in train.
RND	Return to neutral in depression.
CF	Control field.
MS	Master switch.
AS	Action switch.
ECB	Elevation circuit breaker switch.
TCB	Train circuit breaker switch.
FBVR	Feedback voltage resistance.
Tr.	Train.
El.	Elevation.
TRN"a"	Train return to neutral "a" switch.
TRN"b"	Train return to neutral "b" switch.
RNTR	Return to neutral in train relay.
RNDR	Return to neutral in depression relay.
Pot	Potentiometer.
BS	Brake solenoid.
TDM	Turret drive motor.
MR	Master relay.
DRNS	Depression return to neutral switch.
ULS	Upper limit switch.
CON. FOL. ...	Contour follower.

NORMAL OPERATION

Now consider NORMAL OPERATION. What is it? That's when the turret does what you want it to, without arguing. In other words, you have control of the speed and direction of turret movement.

The schematic of normal operation appears in figure 55. You can follow the various operations and their effects by checking

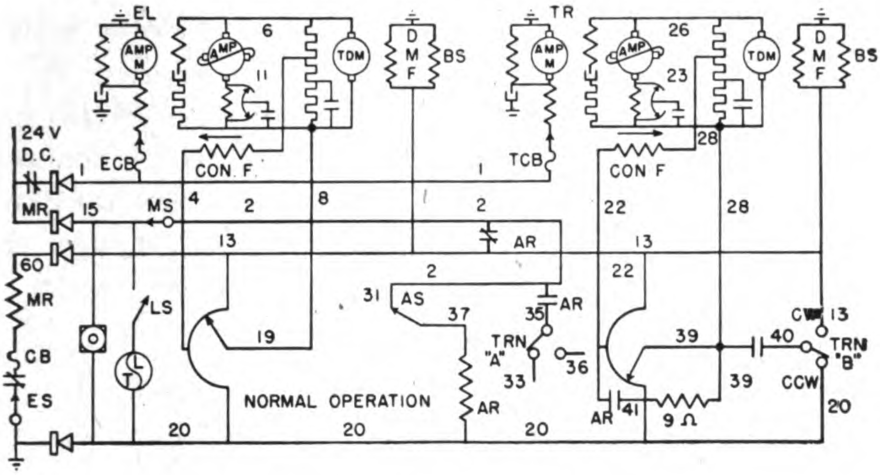


Figure 55.—Normal operation.

with this figure. After you've followed through on normal operations, you can check through the OPERATION and PURPOSE of all the auxiliary circuits.

YOU DO THIS	WHAT HAPPENS?
Close MS and AS.	Current flows through MS and AS picking up AR. AR contact between wires 2 and 13 closes, allowing current to flow through Pot's, BS's, TDM fields and MR. MR contact picks up, placing a 24 v. potential on the amp. CB switches.
Close ECB and TCB, one at a time.	Current flows through amp. drive motors, starting them in operation.
Deflect potentiometer arms as shown.	Current flows from high potential to low potential through CF's, driving turret in desired direction.

THEN WHAT HAPPENS?

TRN"a" switch changes	Wires 35 and 33 are connected.

position when turret leaves stowed position. TRN"b" switch may change position when turret leaves stowed position.	(Indicated by position of TRN"A" switch on schematic). Wires 13 and 40 are connected when turret is in stow in train and remain connected if gun moves clockwise from stow. Wires 20 and 40 are connected if gun moves counterclockwise from stow. (Indicated by position of TRN"B" switch on schematic).

BRAKE SOLENOID OPERATION

One feature of the Grumman turret, which is illustrated in the schematic of normal operation (figure 55) and which you will want to know about, is the BRAKE SOLENOID. Here's how it works.

When the turret is not operating, spring tension holds the brake shoe against the armature. This stops any rotation due to wind or gravity.

When the turret starts operating, the brake solenoid is energized. The magnetic pull of this solenoid is strong enough to overcome the spring tension on the brake shoe, so it pulls the shoe away from the armature, permitting it to rotate freely. Referring again to figure 55, you can see that the brake solenoid is connected in parallel with the TDM field, so that both of them are energized at the same time.

When the current goes off, the solenoid's pull disappears and the spring tension jams on the brakes again.

YOU DO THIS	WHAT HAPPENS?
Close MS, AS and ECB and TCB one at a time.	Turret is placed in normal operation.
Close HSS (See figure 56).	HSS relay contacts actuate, decreasing FBVR and decreasing resistance in parallel with series field. (Indicated by position of HSR contacts on schematic).

RETURNING TO NEUTRAL

When the gunner releases the AS, a special circuit known as the RETURN TO NEUTRAL CIRCUIT goes into operation and automatically brings the turret back to the stowed position, which is horizontal and aft.

This position adds to the streamlining of the airplane. Since the turret stows first in train and then in elevation, the return

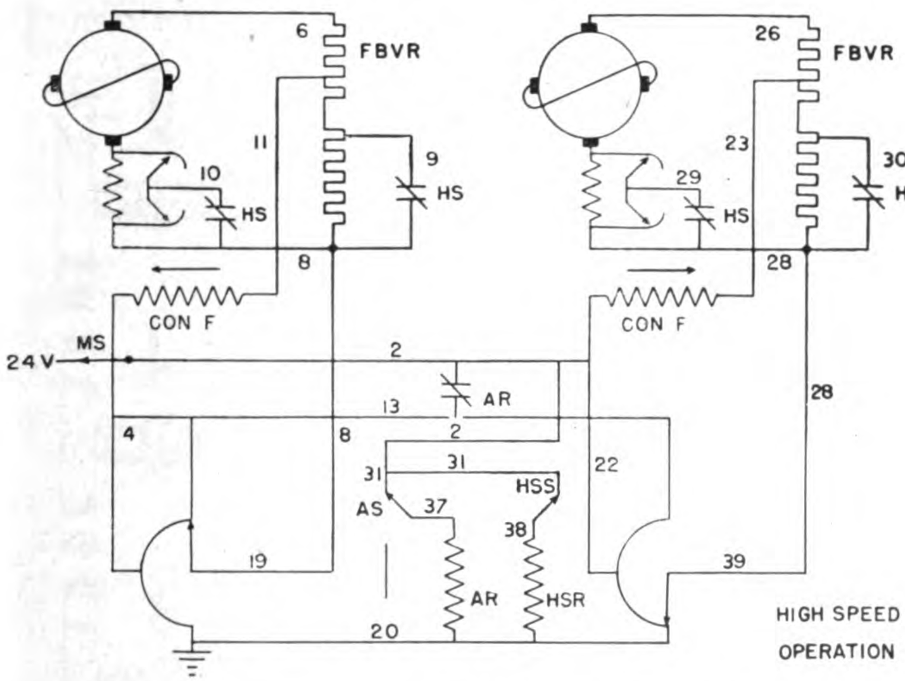


Figure 56.—Normal operation with HSS closed.

to neutral circuit is broken into two separate circuits known as the RNT and RND.

A look at figure 57 will help you understand RNT operation. Notice that the switches are operated mechanically by the STAR WHEEL, which is turned one-quarter of a turn every time it is moved across any one of four STOWING PINS, located around the track and train unit. Two of these pins are located in such a way as to have the star wheel between them whenever the turret is in stowed position in train. These two pins are referred to as the HOME PINS. (See part *A* of figure 57.)

Note in this position the "A" cam is up, actuating the "A" switch connecting wires 35 and 36. The "B" switch is not actuated in this position, so wires 40 and 13 remain connected.

Moving the turret out of stow counterclockwise moves the cams one-quarter turn, as shown in part *B* of figure 57. The "A" switch is actuated again, connecting lines 35 and 33. The "B" switch, whose purpose is to return the turret to stowed position by the SHORTEST ROUTE, is also actuated at this time. It connects line 40 to 20, thus returning the turret to stowed position CLOCKWISE.

Part *C* of figure 57 shows how moving the turret beyond the 180 degree position moves the cams another quarter turn. The

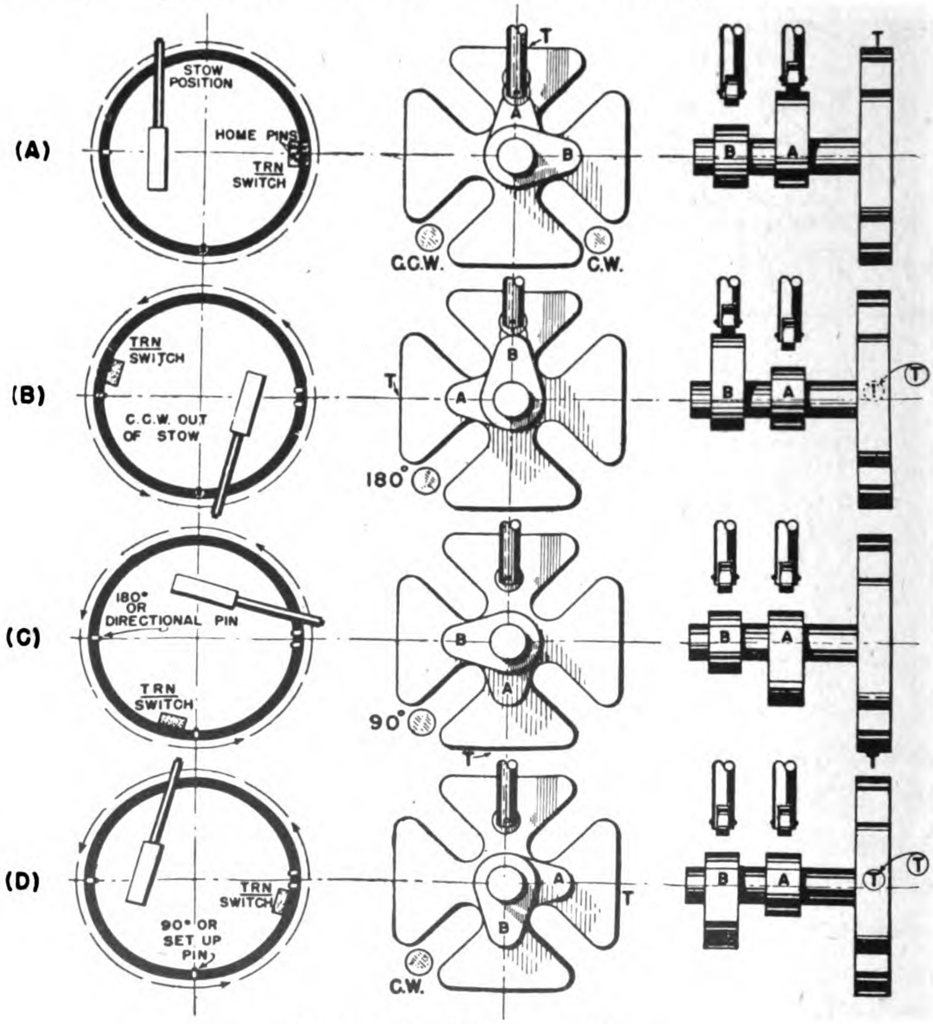


Figure 57.—RNT operation.

"A" switch is still connected to lines 35 and 33. The "B" switch, however, is actuated, connecting lines 40 and 13. This stows the turret COUNTERCLOCKWISE, which is the shortest route.

Now looking at part *D* of figure 57, you'll see that moving the turret 90 degrees more moves the turret across the SET-UP PIN. This movement does NOT actuate either switch, but SETS UP THE CAMS to actuate the "A" switch when the turret comes to the stowed position. It also sets up the cams to actuate the "B" switch for the 180 degree position, should the turret go out of stow CLOCKWISE. Moving the turret 90 degrees more completes one revolution and puts the turret back to the stowed position, as it was originally in part *A* of figure 57.

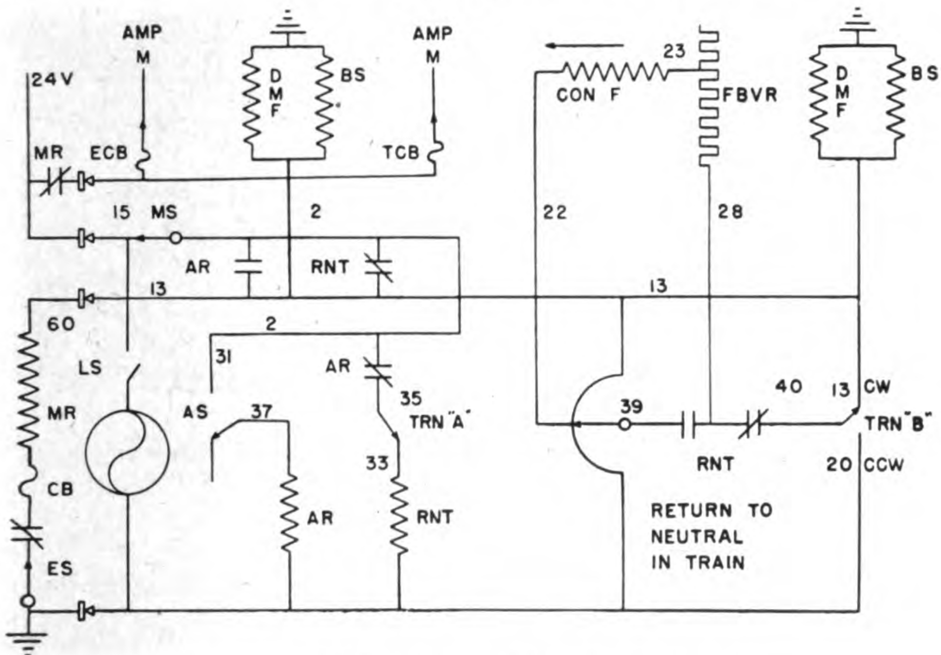


Figure 58.—Operation of the RNT circuit.

YOU DO THIS	WHAT HAPPENS?
Release AS with turret out of stow in train and elevation.	AR drops out, thus closing normally closed contact between wires 2 and 35. Current flows through AR contact and TRN "A" switch, picking up RNTR. RNTR contact between wires 2 and 13 closes and keeps power on Pot's, BS's, TDM fields, and MR. RNTR contacts in CF circuit place 12 v. across CF circuit. The TRN"B" switch determines the polarity of the 12 v. across CF, thus de-

termining direction turret will stow. Turret always stows by shortest path.

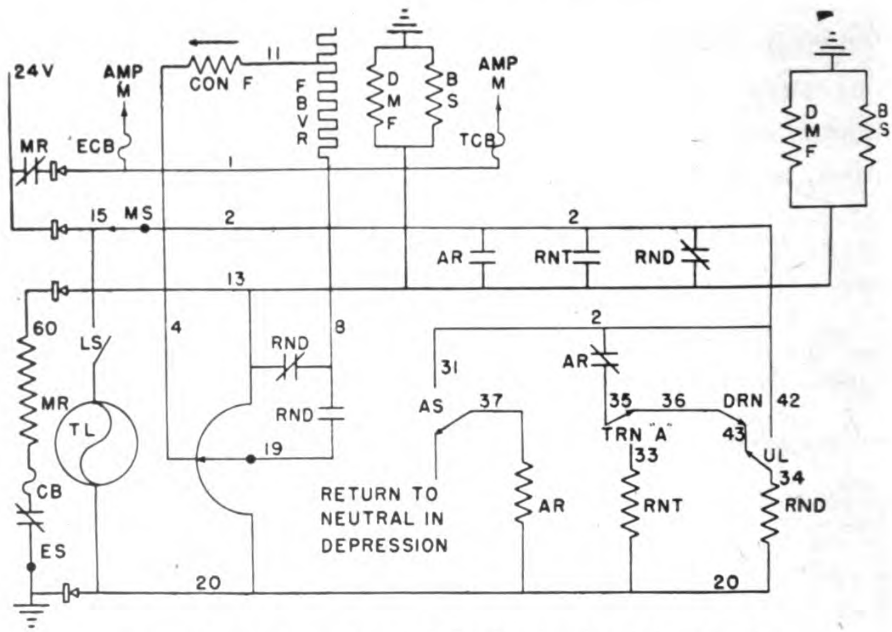


Figure 59.—Operation of RND circuit while stowing.

THEN WHAT HAPPENS?

When the turret reaches the stowed position in train, the TRN"A" switch changes position.

Wires 35 and 33 are disconnected, dropping out the RNT relay and stopping train movement. Wires 35 and 36 are connected, thus current flows through DRNS and ULS picking up RNDR. RNDR contact between wires 2 and 13 closes and keeps power on Pot's, BS's, TDM fields and MR.

RNDR contacts in CF circuit place 12 v. across CF circuit. The polarity of the voltage is always in a direction to drive the turret down.

The DRN switch opens when turret reaches the horizontal position.

Wires 36 and 43 are disconnected, dropping out the RND relay. RNDR contacts actuate, removing power from Pot's, BS's, TDM fields, and MR. MR contact opens and removes power from amp. drive motors. Turret is now secure, horizontal and aft. It will remain in this position, due to the TDM brakes, until proper switches are closed for operation.

CAUTION: Do not close AS until amp. CBS have been opened.

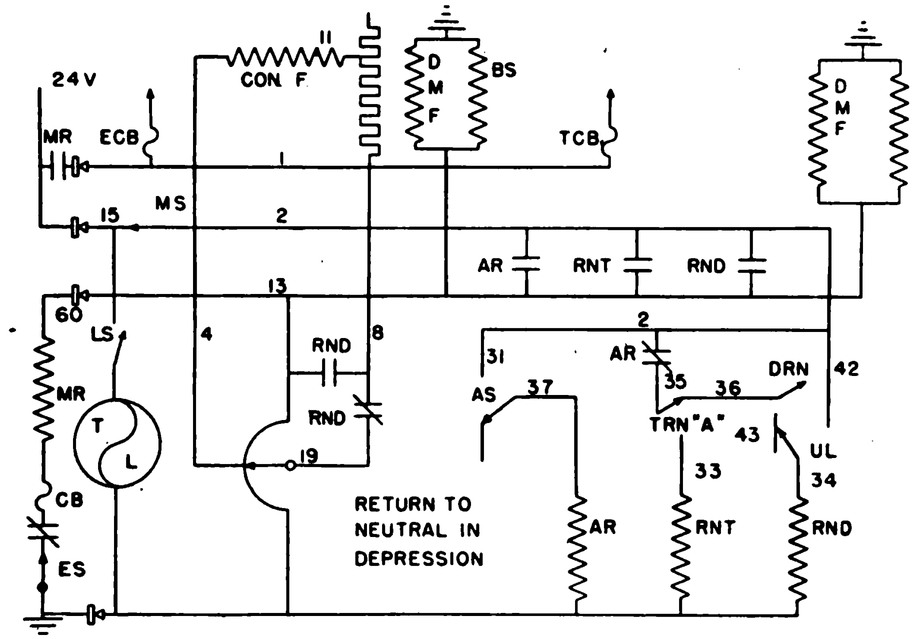


Figure 60.—Position of RND circuit stowed.

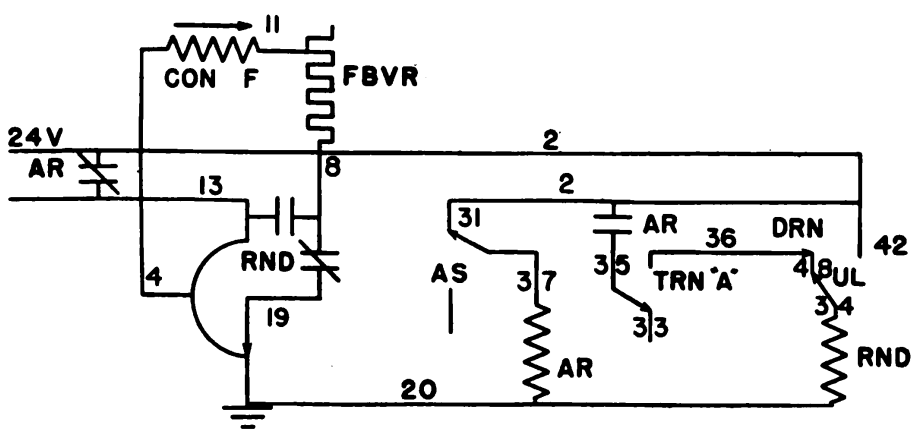


Figure 61.—Upper limit circuit with normal operation of turret.

UPPER LIMIT OPERATION

The limit of gun travel in elevation is 85 degrees. The UL circuit is provided to prevent the gun from going beyond its limit in elevation.

YOU DO THIS	WHAT HAPPENS?
With turret in normal operation, deflect controller in a direction to move turret up.	Current flows up through El. CF circuit from mid-tap to Pot. arm.

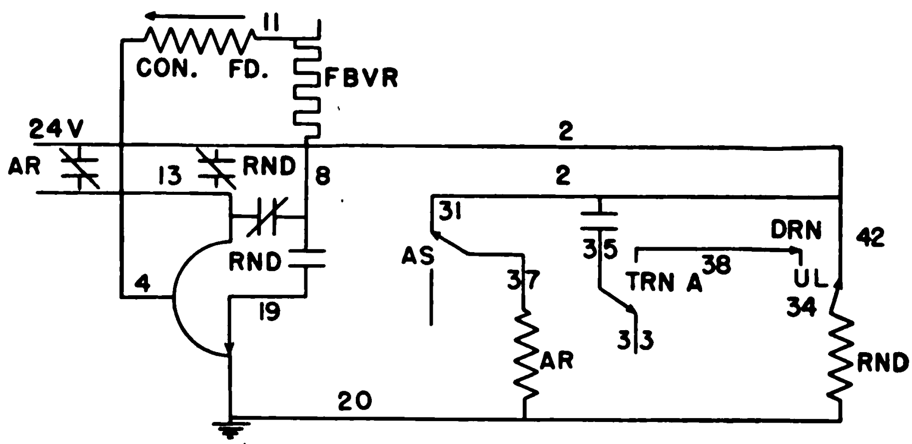


Figure 62.—Upper limit actuates.

THEN WHAT HAPPENS?

Turret reaches 85 degree position where UL switch actuates.	Wires 42 and 34 are connected, thus current flows through UL picking up RNDR. RNDR contacts in the CF circuit actuate and place 12 v. across CF circuit. The polarity of this voltage is the reverse of the voltage due to the potentiometer deflection; therefore, the turret is driven away from the UL position.
Turret moves away from 85 degree position which causes UL switch to assume its normal position.	Wires 42 and 34 are disconnected, dropping out RNDR. RNDR contacts actuate, and turret is again in normal operation.

CONTOUR FOLLOWER OPERATIONS

You will remember that to prevent the gun from physically striking the structure of the aircraft, an electrical device called the CONTOUR FOLLOWER is provided.

Four definite switching steps take place within the first 7/16-inch travel of the CONTOUR FOLLOWER arms.

The following diagrams and explanations of these steps will give you a clear conception of what takes place.

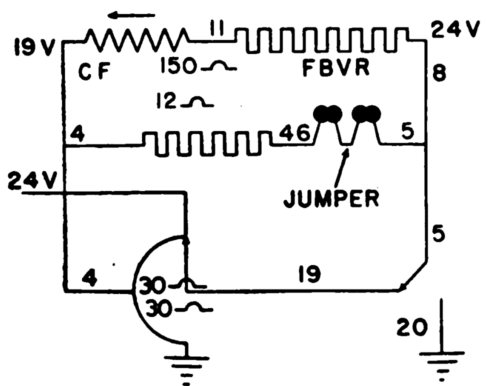


Figure 63.—First step for elevation.

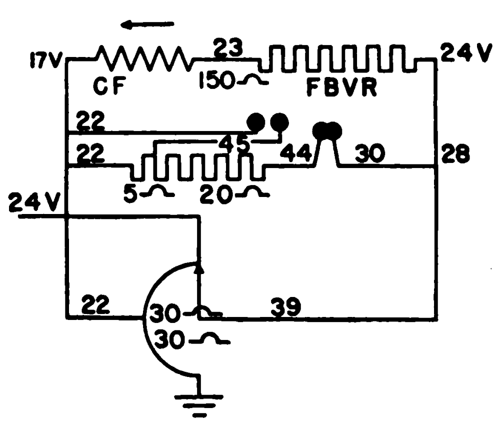


Figure 64.—First step for train.

Contact between the jumper and wire 46 closes, placing 12 ohms in parallel with El. CF.

Contact between wires 30 and 44 close, placing 25 ohms in parallel with Tr. CF.

THEN WHAT HAPPENS?

Turret slows down in El. due to decreasing IR drop across CF. Turret direction is down.

Turret slows down in train due to decreasing IR drop across CF.

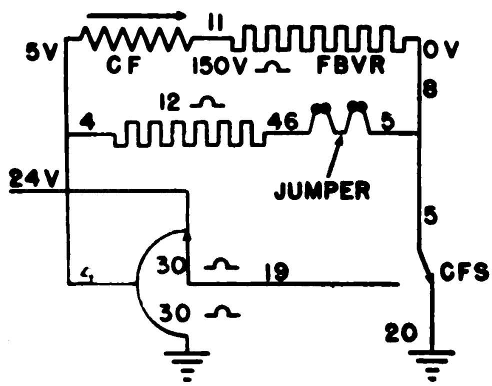


Figure 65.—Second step for elevation.

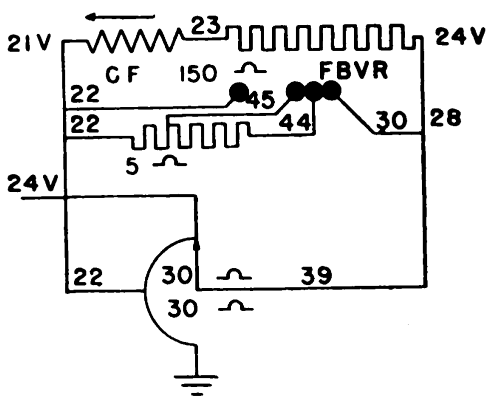


Figure 66.—Second step for train.

CON.FOL micro-switch reverses position. 12 ohms remains in parallel with CF.

Contact between wires 44 and 45 closes, leaving 5 ohms in parallel with CF.

NEXT, WHAT HAPPENS?

Polarity of CF field V is reversed; therefore, turret reverses direction. Turret direction is up.

Turret slows down due to decreased IR drop across CF.

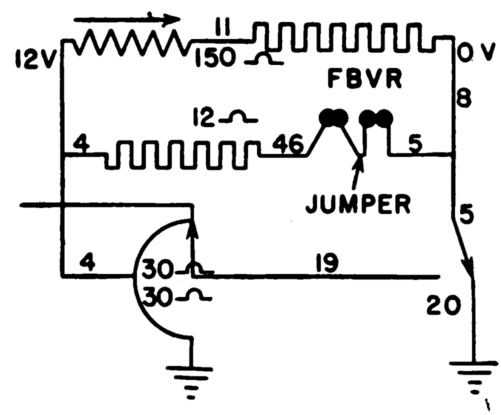


Figure 67.—Third step for elevation.

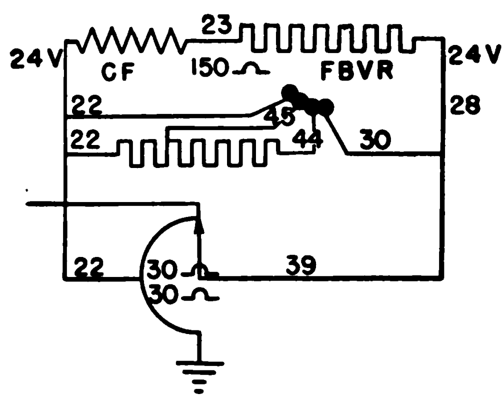


Figure 68.—Third step for train.

Contact between jumper and wire 5 opens, removing the 12 ohms which were across CF.

Contact between wires 45 and 22 closes; therefore shorting CF circuit.

THEN WHAT HAPPENS?

Turret speed increases to full normal, due to 12 v. drop across CF. Turret direction is up.

Turret stops due to no difference in potential between one side of CF and the other.

Contact between wires 31 and 38 close, picking up MSR.

Turret at full high speed in elevation. Nothing happens in train.

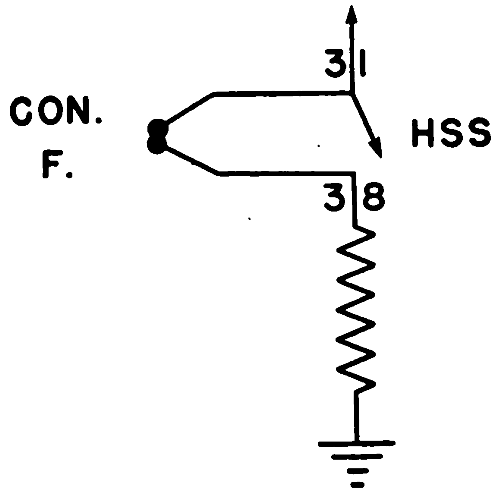


Figure 69.—Fourth step for elevation.

THE 9-OHM RESISTOR CIRCUIT

If the potentiometer handle were accidentally deflected in a direction for train movement while the turret was being stowed in El. by the RND circuit, serious damage to the airplane and

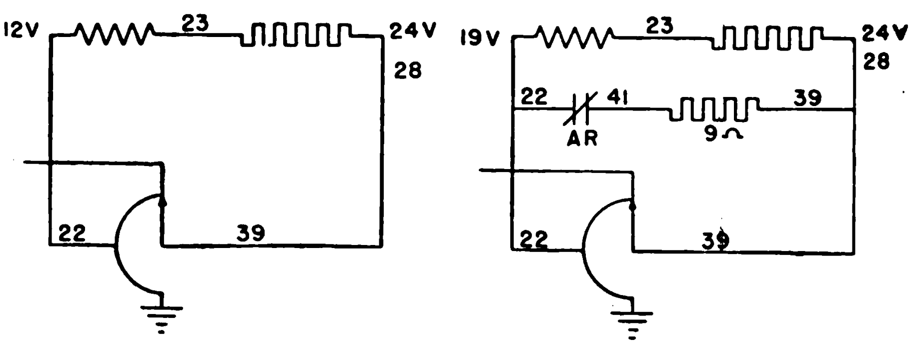


Figure 70.—CF circuit with and without 9-ohm resistor.

turret would result unless the potentiometer handle were returned to the correct position. Here's why —

Since the turret is stowing in El., the train potentiometer is excited and will furnish current for the train control field. If there were no way provided to limit the current flowing through the train control field, the turret would respond and move quickly out of stow, at which time the star wheel would actuate the TRN "a" switch. As soon as this switch was actuated, the RND circuit would drop out and the RNT circuit would pick up, stowing the turret immediately in train. This operation would be repeated as long as the potentiometer handle remains deflected and until the turret finally stows in elevation.

It is to prevent this undesirable situation that the 9-ohm resistor circuit is provided. The 9-ohm resistor circuit is placed in parallel with the train CF when the AS is released by the AR normally closed contact.

A comparison of the train CF circuit with and without the 9-ohm resistor is shown in figure 70. A full potentiometer deflection is shown, although any deflection will result in turret movement.

The first diagram shows voltage across CF without the 9-ohm resistor. 'The result of this voltage will cause the turret to oscillate violently.

In the second diagram voltage is shown across CF with the 9-ohm resistor in the circuit. The result of this voltage will allow the turret to move out of stow slowly, but no severe oscillations result.

The schematic in figure 71 ties together ALL the circuits of the Grumman 150 SE–2. Look it over and notice how it includes the basic amplidyne system PLUS the various auxiliary circuits.

TRACKING DOWN TROUBLE

During World War II no one succeeded in designing a turret which would just keep running along smoothly under any and all conditions.

Even with a slick job like the Grumman 150 SE–2 you're bound to have breakdowns. And when trouble comes, you'll want to locate the fault QUICKLY and then FIX IT UP.

The trouble shooting charts on the following pages are designed to help you RECOGNIZE and SPOT what has gone wrong when a turret goes bad on you. Further, the charts show what to do about it.

Before you start checking over the charts, remember this — START AT THE BEGINNING. The steps follow a definite order.

You'll need a voltmeter and an ohmmeter to help you localize exactly where the fault lies in the circuit.

DON'T RUSH! Trouble shooting takes patience.

There's an old saying "Where there's smoke, there's fire." In trouble shooting, you can keep this old adage from coming true. If you see smoke, SECURE ALL SWITCHES. Then check the circuit with an ohmmeter.

Naturally, if you're going to be a troubleshooter who gets results, you have to know what you're doing. You must have a complete understanding of the Grumman amplidyne and auxiliary circuits, and you must know how to use a voltmeter and ohmmeter.

Now take a look at the trouble shooting charts. Numbers used check with the schematic in figure 71. You can see that it ties together all the circuits discussed in this chapter.

TROUBLE SHOOTING PROCEDURE FOR NORMAL OPERATION

FIRST STEP

Open all switches. Check position of star wheel to see if "T" is up between two home pins. Place turret in a position to make the AR visible. Close MS and AS.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
AR picks up. Proceed to second step.	AR fails to pick up.	Low source voltage, or AR circuit is open, or AR is mechanically faulty, or too much spring tension on AR.
	AR chatters.	Low source voltage, or resistance is being introduced into AR circuit, or AR is miswired, or AR is internally or externally shorted.
	Smoke is seen.	AR circuit, wire 13 circuit, or amp. drive motor circuit is grounded.
	Either or both amp's. run.	Amp. switch or switches are internally or externally shorted.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
	Wrong relay operates.	AR circuit is miswired or shorted to wrong relay, or 24 v. is shorted to wrong relay.

SECOND STEP

Close ECB and TCB, one at a time. Disregard turret action.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
El. & Tr. amp. motors run without sparking excessively and there is no excess vibration. Proceed to third step.	El. amp. motor does not run.	Open in El. amp. motor circuit after MR contact.
	Tr. amp. motor does not run.	Open in Tr. amp. motor circuit after MR contact.
	Neither of the amp. motors run.	AR normally open contact between wires 2 and 13 is not closing when AR is picked up, or MR coil circuit is open, or MR contact is not closing, due to mechanical failure, or open circuit between MR contact and amp. CB switches.
	El. amp. motor sparks excessively.	Brushes are faulty, or brush rigging is shifted from normal position.
	Tr. amp. motor sparks excessively.	Brushes are faulty, or brush rigging is shifted from normal position.
	El. amp. CB kicks out.	El. amp. motor circuit is grounded, or El. amp. motor armature is frozen.
	Tr. amp. CB kicks out.	Tr. amp. motor circuit is grounded, or Tr. amp. motor armature is frozen.
	Tr. amp. vibrates excessively.	Tr. amp. motor armature is unbalanced, or Tr. amp. bearings are faulty.
	El. amp. vibrates excessively.	El. amp. motor armature is unbalanced, or El. amp. bearings are faulty.

THIRD STEP

With AS, MS, ECB, and TCB closed, deflect Pot. in Tr. and El. so as to move turret a few degrees in both directions.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
Turret operates normal in Tr. and El. proceed to fourth step.	Turret does not operate normal in Tr., but amp. does not sound overloaded.	Refer to figure 72, page 96 and check as indicated.
	Turret does not operate normal in El., but amp. does not sound overloaded.	Refer to figure 72, page 96 and check as indicated.
	Tr. amp. sounds overloaded.	Wire 13 feeding BS and TDM field is open, or BS is open, or TDM field is open, or TDM armature is internally or externally shorted, or TDM armature is frozen, or BS is mechanically faulty.
	El amp. sound overloaded.	Wire 13 feeding BS and TDM field is open, or BS is open, or TDM field is open or TDM armature is internally or externally shorted, or TDM armature is frozen, or BS is mechanically faulty.

FOURTH STEP

With turret in operation, fully deflect controller in train and clock speed of turret. (HSS is not to be actuated.)

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
Turret makes one revolution in 18 seconds. Proceed to fifth step.	Turret makes one revolution in more than 18 seconds.	Too much FBVR.
	Turret makes one revolution in less than 18 seconds.	Not enough FBVR.

FIFTH STEP

With turret in operation, fully deflect controller in train and clock speed of turret with HSS closed.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
Turret makes one revolution in 8 seconds. Proceed to sixth step.	Turret makes one revolution in more than 8 seconds.	Too much FBVR when HSS is closed, or not enough R. in parallel with series field when HSS is closed.
	Turret makes one revolution in less than 8 seconds.	Not enough FBVR when HSS is closed.
	Turret speed does not change when HSS is closed.	HSR is not picking up when HSS is closed, or HSR contacts are faulty, or wires 28 or 30 are open feeding HSR contact.
	Turret stops or almost stops when HSS is closed.	Not enough HS compounding resistance.

SIXTH STEP

With turret in operation, close HSS and place load on turret in train.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
Turret does not speed up or slow down under load. Proceed to seventh step.	Turret speeds up under load.	Too much resistance in parallel series field with HSS closed.
	Turret slows down under load.	Not enough resistance in parallel with series field with HSS closed.
	Turret has tendency to hunt.	Too much resistance in parallel with series field with HSS closed, or anti-hunt field is open or shorted.

SEVENTH STEP

With turret in operation, place load on turret in train.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
Turret does not speed up or slow down under load. Proceed to eighth step.	Turret speeds up under load.	Too much resistance in parallel with series field.
	Turret slows down under load.	Not enough resistance in parallel with series field.

EIGHTH STEP

With turret in operation, fully deflect controller in elevation and make visual check of turret speed. (HSS is not to be actuated.)

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
Turret speed is normal. Proceed to ninth step.	Turret speed is less than normal.	Too much FBVR.
	Turret speed is more than normal.	Not enough FBVR.

NINTH STEP

With turret in operation, fully deflect controller in elevation and make visual check of turret speed with HSS closed.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
Turret speed is normal. Proceed to tenth step.	Turret speed is less than normal.	Too much FBVR when HSS is closed, or not enough R. in parallel with series field when HSS is closed.
	Turret speed is faster than normal.	Not enough FBVR when HSS is closed.
	There is no change in turret speed when HSS is closed.	HSR is not picking up when HSS is closed, or HSR contacts are faulty, or wires 9 or 8 are open feeding HSR contact.
	Turret stops or almost stops when HSS is closed.	Not enough HSS compounding resistance.

TENTH STEP

With turret in operation, close HSS and place load on turret in elevation.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
Turret does not speed up or slow down under load. Proceed to eleventh step.	Turret speeds up under load.	Too much resistance in parallel with series field with HSS closed.
	Turret has tendency to hunt.	Too much resistance in parallel with series field with HSS closed, or anti-hunt field is open or shorted.

ELEVENTH STEP

With turret in operation, place load on turret in elevation.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
Turret does not speed up or slow down under load. Proceed to sixteenth step.	Turret speeds up under load.	Too much resistance in parallel with series field.
	Turret slows down under load.	Not enough resistance in parallel with series field.

TWELFTH STEP

Close AS and MS. Connect VM across train CF and deflect control handle until VM reads approximately 4 v. Close TCB.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
VM reading should decrease to approximately .7 v. Proceed to fourteenth step.	VM reading increases.	Wires 22 and 23 are reversed, feeding CF, or wires 26 and 28 are reversed feeding FBVR.
	VM reading does not change.	Wires 26 and 28 are not connected across FBVR, or FBVR is open above wire 23, or either 26 or 28 is open feeding FBVR, or amp. generator armature is open, or series field is shorted.
	VM reading decreases to approximately .1 v.	FBVR is open below wire 23, or there is too much FBVR.
	VM reading decreases to 0 v. and then off scale.	Turret is over-compounded, or there is too much FBVR.
	VM reading decreases slightly.	Series field is shorted, or short circuit wire is open, or faulty brushes, or faulty armature.
	VM reading decreases to approximately 1 v.	Not enough FBVR.

THIRTEENTH STEP

Close AS and MS. Connect VM across El. CF and deflect control handle until VM reads approximately 4 v. Close ECB.

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WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
VM reading should decrease to approximately .7 v. Proceed to fifteenth step.	VM reading increases.	Wires 11 and 4 are reversed feeding CF, or wires 6 and 8 are reversed feeding FBVR.
	VM reading does not change.	Wires 6 and 8 are not connected across FBVR, or FBVR is open above wire 11, or either 6 or 8 is open feeding FBVR, or amp. generator armature is open, or series field is shorted.
	VM reading decreases to approximately .1 v.	FBVR is open below wire 11, or there is too much FBVR.
	VM reading decreases to 0 v. and then off scale.	Turret is over-compounded or there is too much FBVR.
	VM reading decreases slightly.	Series field is shorted, or short circuit wire is open, or faulty brushes, or faulty armature.
	VM reading decreases to approximately 2 v.	Anti-hunt condenser is internally or externally shorted, or series field is shorted, or short circuit wire is open, or faulty brushes, or faulty armature.
	VM reading decreases to approximately 1 v.	Not enough FBVR.

FOURTEENTH STEP

Place turret in operation in train and note exact symptoms.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
	Turret has tendency to hunt.	Anti-hunt circuit is open, or turret is over-compounded, or anti-hunt field is shorted.
	Turret operates reverse of control.	Wires 26 and 28 are reversed between FBVR and TDM armature.
	Turret speed is slow.	Anti-hunt condenser is shorted, or turret is under-compounded, or too much FBVR, or amplidyne brushes are bad, or amplidyne short circuit is open, or brush rigging is not adjusted properly.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
	Turret creeps.	Turret is over-compounded, or Pot. arm is not at neutral position on Pot. coil.
	Turret speed is fast.	Not enough FBVR.
	Turret will not move.	Either wire 26 or 28 between FBVR and TDM is open, or TDM armature is open.
	Turret cannot be moved out of stow in train.	AR normally closed contact between wires 2 and 35 is shorted.

FIFTEENTH STEP

Place turret in operation in elevation and note exact symptoms.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
	Turret has tendency to hunt.	Anti-hunt circuit is open, or turret is over-compounded, or anti-hunt field is shorted.
	Turret operates reverse of control handle deflection.	Wires 6 and 8 are reversed between FBVR and TDM armature.
	Turret speed is slow.	Anti-hunt condenser is shorted, or turret is under-compounded, or too much FBVR, or amplidyne brushes are bad, or amplidyne short circuit is open, or brush rigging is not adjusted properly.
	Turret creeps.	Turret is over-compounded, or Pot. arm is not at neutral position on Pot. coil.
	Turret will not move.	Either wire 6 or 8 between FBVR and TDM is open, or TDM armature is open.
	Turret speed is fast.	Not enough FBVR.
	Turret cannot be moved out of stow in El.	24 v. is shorted to wire 36.

TROUBLE SHOOTING PROCEDURE FOR RNT OPERATION

SIXTEENTH STEP

Open the ECB. Make certain that turret is out of stow in train and elevation and in operation. Release AS.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
Turret stows properly in train and amplidyne continues to run. Proceed to seventeenth step.	Turret secures and amp's. cease running.	RNT relay circuit is open, or RNT relay is mechanically faulty, keeping normally open contact between wires 2 and 13 open, or RNT relay contact circuit between wires 2 and 13 is open.
	Amp's. continue to run but there is an improper stowing action.	Refer to figure 76, page 103, and check as indicated.
	Turret stows properly in Tr. and then secures. Amp's. cease running.	RND relay circuit is open, or RND relay is mechanically faulty keeping normally open contact between wires 2 and 13, open, or RND relay contact circuit between wires 2 and 13 is open.
	RNT relay chatters when AS is released.	RNT relay coil is miswired, or RNT relay coil is internally or externally shorted.
	RND relay chatters when turret reaches stowed position in Tr.	RND relay coil is miswired, or RND relay coil is internally or externally shorted.
	Turret begins hunting when stowed position in Tr. is reached.	RNT relay is miswired keeping RNT contacts in circuit, or TRN"b" switch is being actuated before TRN"a" switch due to mis-adjustment of TRN cams, or RNT normally closed contact is failing to close when stowed in position in Tr. is reached.

TROUBLE SHOOTING PROCEDURE FOR RND OPERATION

SEVENTEENTH STEP

Open the TCB. Make certain turret is in operation, out of stow in elevation, and in stow in train.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
Turret stows properly in elevation and turret secures. Amp's. cease running. Proceed to eighteenth step.	Amp's. continue to run but there is improper action from the time the AS is released.	Refer to figure 77, page 104, and check as indicated.
	Turret depresses to the horizontal in a normal operation and then continues downward below the horizontal. Amp's. do not secure.	DRN switch is not being actuated by DRN cam, or DRN switch is internally or externally shorted, or RND relay is mechanically faulty, keeping RND relay contacts in circuit, or RND relay is miswired, keeping RND relay contacts in circuit.
	Turret depresses to the horizontal in a normal operation where turret operation ceases but amp's. continue to run.	MR contacts are internally or externally shorted, or wire 13 has 24 v. shorted to it.

EIGHTEENTH STEP

Place turret in operation in train and elevation. Make certain turret is out of stow in both train and elevation, and then release AS.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
Turret stows in Tr. and El. normally and secures. Amp's. cease running. Proceed to nineteenth step.	Turret starts to stow in Tr. and El. at the same time.	The RND and RNT relays are shorted together.

TROUBLE SHOOTING PROCEDURE FOR UL OPERATION

NINETEENTH STEP

Place turret in operation in elevation and train and operate the UL switch.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
Turret depresses in El. at normal speed as long as UL is actuated. Proceed to twentieth step.	Turret does not depress.	Wire 2 or 42 feeding UL switch is open, or UL switch is faulty.

TROUBLE SHOOTING PROCEDURE FOR CON.FOL. OPERATION

TWENTIETH STEP

Place turret in operation in elevation at the horizontal and actuate the contour follower arms slowly to a maximum deflection.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
Turret should operate in following sequence: Turret slows down. Turret reverses direction. Turret operates at normal speed. Turret operates at HS. Proceed to twenty-first step.	Turret does not respond to Con.Fol. as it should.	Proceed to twenty-third step and check as indicated.

TWENTY-FIRST STEP

Place turret in operation in train and actuate the contour follower arms slowly to a maximum deflection.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
Turret should operate in following sequence: Turret slows down. Turret slows down more. Turret completely stops. Proceed to twenty-fourth step.	Turret does not respond to Con.Fol. as it should.	Proceed to twenty-second step and check as indicated.

TWENTY-SECOND STEP

Close MS and AS. Connect VM across Tr. CF and deflect control handle until VM reads approximately 3 v. Actuate Con.Fol. arms slowly to their maximum deflection.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
VM should vary its reading in following sequence: VM reading decreases to 2 v. VM reading decreases to 1 v. VM reading decreases to 0 v.	Contour follower arms have to be actuated too far before VM reading changes for first step in sequence.	Improper mechanical adjustment of Con. Fol. arms, or improper adjustment of finger contact between wires 30 and 44.
	VM readings does not vary according to sequence.	Finger contacts are improperly adjusted, or wire or wires feeding finger contacts are open.
	Displacement of contour follower arms is greater for one step than it is for another.	Finger contacts are improperly adjusted.
	VM reading does not change regardless of contour follower deflection.	Either wire 22, 28, 30, or 44 is open, failing to place Con.Fol. resistance across CF.

TWENTY-THIRD STEP

Close MS and AS. Connect VM across El. CF and move control handle up until VM reads approximately 3 v. Actuate contour follower arms slowly to their maximum deflection.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
VM should vary its reading in following sequence: VM reading decreases to 1.5 v. VM reading reverses polarity but magnitude remains 1.5 v. VM reading increases to 3 v. VM reading increases to 4.5 v.	Con.Fol. arms have to be actuated too far before VM reading changes for first step in sequence.	Improper mechanical adjustment of Con. Fol. arms, or improper adjustment of finger contact between wire 46 and the jumper.
	VM readings do not vary according to sequence.	Finger contacts are improperly adjusted, or Con. Fol. micro-switch is improperly adjusted, or wire or wires feeding finger contacts are open, or wire or wires feeding micro-switch are open.
	Displacement of Con. Fol. arms is greater for one step than it is for another.	Finger contacts are improperly adjusted, or micro-switch is improperly adjusted.

TROUBLE SHOOTING PROCEDURE FOR 9-OHM RESISTOR OPERATION

TWENTY-FOURTH STEP

Place turret in operation in train out of stow and release AS. Deflect control handle to a maximum in both directions while turret is stowing.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
Turret speeds up with one deflection and slows down with the opposite deflection.	Turret neither speeds up nor slows down.	9-ohm resistor circuit is open.
	Turret completely stops with a maximum deflection in one direction and runs at a very high speed with the opposite deflection.	9-ohm resistor is internally or externally shorted.

CHECKING THE VOLTAGE

The rest of the pages in this chapter are devoted to VOLTAGE CHECKS, which are used in conjunction with certain steps of this trouble shooting procedure, as indicated. In diagnosing turret troubles, your VOLTMETER is just as valuable to you as

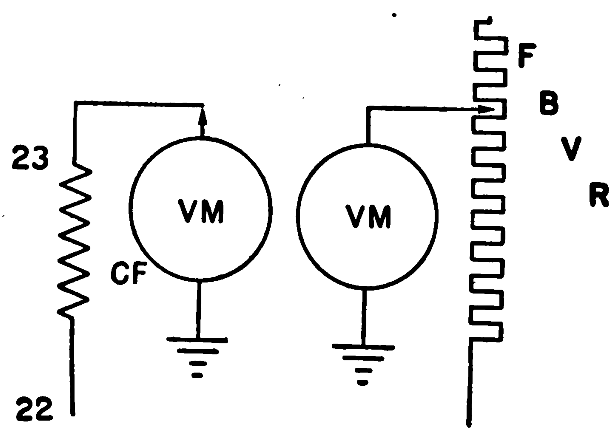


Figure 72.

No deflection of controller.	Begin at neutral and deflect controller slowly to a maximum left deflection.	Begin at neutral and deflect controller slowly to a maximum right deflection.

a doctor's STETHOSCOPE is to him. Voltage readings are very helpful in establishing just what is wrong (or right) in a turret circuit.

Now go on to the lists of voltage checks.

Open all switches. Remove wire 23 from FBVR and connect VM as shown. Close MS and AS. Make and record the three mid-tap voltage checks. Change the VM from wire 23 to FBVR. Make and record the three Pot. arm voltage checks. Compare your voltage readings with those shown to find fault.

Mid-tap	Pot. Arm	Mid-tap	Pot. Arm	Mid-tap	Pot. Arm
12	12	12	12–0	12	12–24

These are normal voltage checks. Proceed to figure 74 and check as indicated

0	0	0–12	0	0	0 (smoke)

Pot. arm circuit or floating circuit is grounded. RNT contact between wires 40 and 28 is shorted.

12	0	12	0	12	0

Pot. arm circuit is open. RNT contacts in CF circuit are reversed or miswired.

0	0	0	0	0	0–24

Mid-tap circuit is grounded.

0	12	0	12–0	0	12–24

Mid-tap circuit is open.

12	24	12	24	12	24

RNT contacts in CF circuit are reversed or miswired.

12	12	12–0	12	12–24	12

Mid-tap and Pot. arm circuits are reversed.

24	24	24	24	24	24

Potentiometer coil is not grounded.

0	0	0	0	0	0

Wire 13 is open feeding Pot., or Pot. coil is open at extreme end. Mid-tap and Pot. arm circuits are both open.
Mid-tap circuit is grounded and Pot. arm circuit is open. Pot. arm circuit is grounded and mid-tap circuit is open.

Mid-tap	Pot. Arm	Mid-tap	Pot. Arm	Mid-tap	Pot. Arm
24	24	24	24–0	24	24

Mid-tap circuit is receiving 24 v. due to a short.

10	10	10–12	10–0	10–12	10–24

Anti-hunt circuit is grounded.

12	might be 0–12	12	VM reads uneven	12	VM reads uneven

Pot. arm is not making good contact with Pot. coil.

12	12	12–0	12–0	12–24	12–24

Mid-tap circuit is shorted to Pot. arm circuit.

0	0	0	0	0	VM jumps 0–24

Train Pot. coil is open above mid-tap.

24	24	24	VM jumps 24–0	24	24

Train Pot. coil is open below mid-tap.

12	12	12–8	12–0	12–16	12–24

Contour follower finger contact between wires 44 and 30 are closed, placing 25 ohms in parallel between mid-tap and Pot. arm.

12	12	12–2	12–0	12–22	12–24

Contour follower finger contact between wires 44, 30, and 45 is closed, placing 5 ohms in parallel between mid-tap and Pot. arm.

12	12	12–4	12–0	12–20	12–24

AR normally open contact between wires 22 and 41 is closed, placing 9 ohms in parallel between mid-tap and Pot. arm.

12	13	12	13–0	12	13–24
12	11	12	11–0	11	11–24

Pot, arm is not at neutral position on Pot. coil.

24	24	24	24 (smoke)	24–12	24

Pot. arm is shorted to 24 v. RNT contact between wires 28 and 40 is shorted.

Open all switches. Remove wire 11 from FBVR and connect VM as shown. Close MS and AS. Make and record the three mid-tap voltage checks. Change the VM from wire 11 to FBVR. Make and record the three Pot. arm voltage checks. Compare your voltage readings with those shown to find fault.

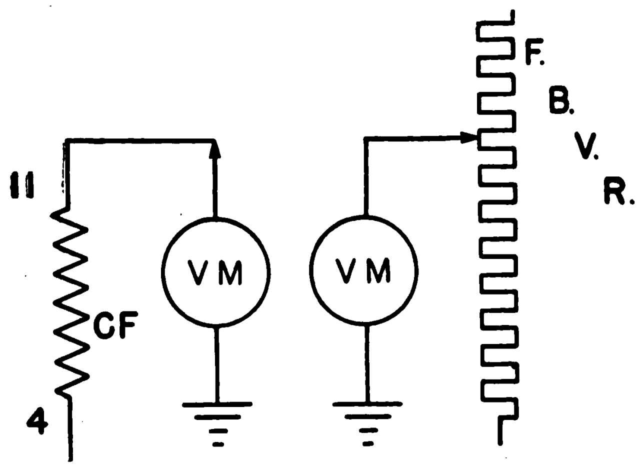


Figure 73.

No deflection of controller.		Begin at neutral and deflect controller slowly to a maximum down deflection.		Begin at neutral and deflect controller slowly to a maximum up deflection.	
Mid-tap	**Pot. Arm**	**Mid-tap**	**Pot. Arm**	**Mid-tap**	**Pot. Arm**
12	**12**	**12**	**12–0**	**12**	**12–24**

These are normal voltage checks. Proceed to figure 75 page 102, and check as indicated.

0	**0**	**0–12**	**0**	**0**	**0 (smoke)**

Pot. arm circuit or floating circuit is grounded.

12	**0**	**12**	**0**	**12**	**0**

Pot. arm circuit is open. Contour follower micro-switch is actuated or miswired.

0	**0**	**0**	**0**	**0**	**0–24**

Mid-tap circuit is grounded.

0	**12**	**0**	**12–0**	**0**	**12–24**

Mid-tap circuit is open.

12	**24**	**12**	**24**	**12**	**24**

RND contacts in CF circuit are reversed or miswired.

12	**12**	**12–0**	**12**	**12–24**	**12**

Mid-tap and Pot. arm circuits are reversed.

24	**24**	**24**	**24 (smoke)**	**24–12**	**24**

RND normally open contact between wires 13 and 8 is shorted.
Pot. arm circuit is shorted to 24 v.

24	**24**	**24**	**24**	**24**	**24**

Pot. coil is not grounded.

0	**0**	**0**	**0**	**0**	**0**

Wire 13 is open feeding Pot., or Pot. coil is open at extreme end.
Mid-tap and Pot. arm circuits are both open.
Mid-tap circuit is grounded and Pot. arm circuit is open.
Pot. arm circuit is grounded and mid-tap circuit is open.

24	**24**	**24**	**24–0**	**24**	**24**

Mid-tap circuit is receiving 24 v. due to a short.

10	**10**	**10–12**	**10–0**	**10–12**	**10–24**

Anti-hunt circuit is grounded.

12	**might be 0–12**	**12**	**VM reads uneven**	**12**	**VM reads uneven**

Pot. arm is not making good contact with Pot. coil.

12	**12**	**12–0**	**12–0**	**12–24**	**12–24**

Mid-tap circuit is shorted to Pot. arm circuit.

0	**0**	**0**	**0**	**0**	**VM jumps 0–24**

El. Pot. coil is open above mid-tap.

24	**24**	**24**	**VM jumps 24-0**	**24**	**24**

El. Pot. coil is open below mid-tap.

12	**12**	**12**	**13–0**	**12**	**13–24**
12	**11**	**12**	**11–0**	**12**	**11–24**

Pot. arm is not at neutral position on Pot. coil.

12	**12**	**12–6**	**12–0**	**12–18**	**12–24**

Contour follower finger contact between wire 46 and the jumper is closed, placing 12 ohms in parallel with the CF.

Open MS and AS. Replace wire 23 on FBVR. Close MS and AS. Check IR drop across CF with no deflection. Next, check IR drop across Tr. CF with one full deflection in train and then the other, according to directions. Record readings. Compare your voltage checks with those shown to find fault.

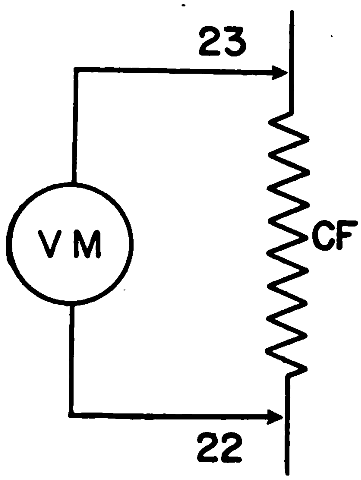


Figure 74.

No deflection of controller.	Begin at neutral and deflect controller slowly to a maximum left deflection.	Begin at neutral and deflect controller slowly to a maximum right deflection.
VM reads	VM reads	VM reads
0	0 to approx. 4 v.	0 to approx. 4 v.

These are normal voltage checks. Go back to twelfth step and check as indicated there.

0	0–12	0–12

FBVR is internally or externally shorted.

0	0	0

CF is internally or externally shorted.

small voltage	not necessary	not necessary

Pot. arm is out of adjustment, therefore, not at neutral position on Pot. coil.

0	0 to approx. 6 v.	0 to approx. 6 v.

There is not enough FBVR.

0	0 to approx. 2 v.	0 to approx. 2 v.

Go back to twelfth step and check as indicated there.

Open MS and AS. Replace wire 11 on FBVR. Close MS and AS. Check IR drop across CF with no deflection. Next, check IR drop across El. CF with one full deflection in El. and then the other, according to directions. Record readings. Compare your voltage checks with those shown to find fault.

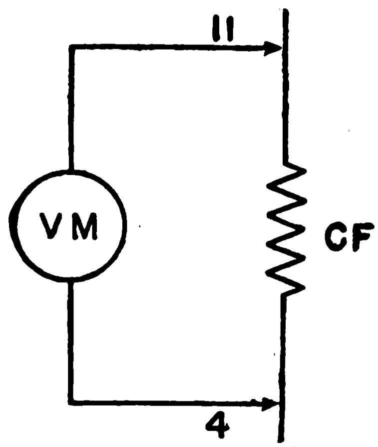


Figure 75.

No deflection of controller.	Begin at neutral and deflect controller slowly to a maximum down deflection.	Begin at neutral and deflect controller slowly to a maximum up deflection.
VM reads	**VM reads**	**VM reads**
0	**0 to approx. 4 v.**	**0 to approx. 4 v.**

These are normal voltage checks. Go back to thirteenth step and check as indicated there.

0	**0–12**	**0–12**

FBVR is internally or externally shorted.

0	**0**	**0**

CF is internally or externally shorted.

small voltage	**not necessary**	**not necessary**

Pot. arm is out of adjustment, therefore not at neutral position on Pot. coil.

0	**0 to approx. 6 v.**	**0 to approx. 6 v.**

There is not enough FBVR.

0	**0 to approx. 2 v.**	**0 to approx. 2 v.**

There is too much FBVR. Go back to thirteenth step and check as indicated there.

Open all switches and place turret out of stow in train clockwise. Remove wire 23 from FBVR and connect VM as shown. Close MS. Make and record the mid-tap and Pot. arm voltage checks. Compare your voltage readings with those shown to find fault.

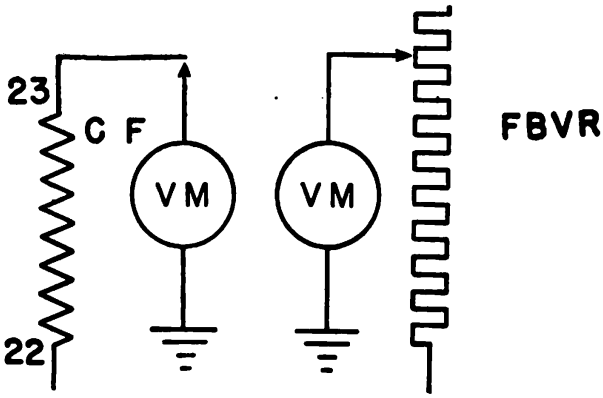


Figure 76.

No deflection of controller

Mid-tap	Pot. arm
12	24

Wire 20 is open between TRN"b" switch and turret frame. TRN"b" switch is not connecting wire 40 to wire 20.

12	0

RNT normally open contact between wires 28 and 40 is not closing. Wire 40 is open.
TRN"b" switch is not connecting wire 13 to wire 40 as it should when turret is out of stow clockwise.
Wire 13 is open feeding TRN"b" switch.

24	24

The normally closed RNT contact between wires 39 and 28 is internally or externally shorted.

12	12

Wires feeding RNT and RND relays are reversed.
RNT relay is open and wire 13 is shorted to 24 v.

Open all switches and place turret out of stow in El. Remove wire 11 from FBVR and connect VM as shown. Close MS. Make and record the mid-tap and Pot. arm voltage checks. Compare your voltage readings with those shown to find fault.

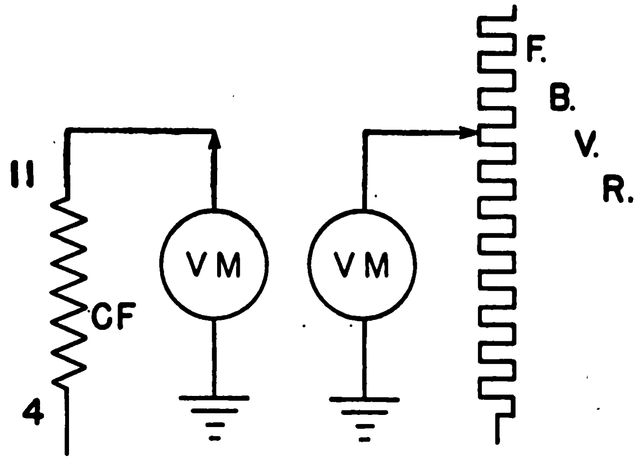


Figure 77.

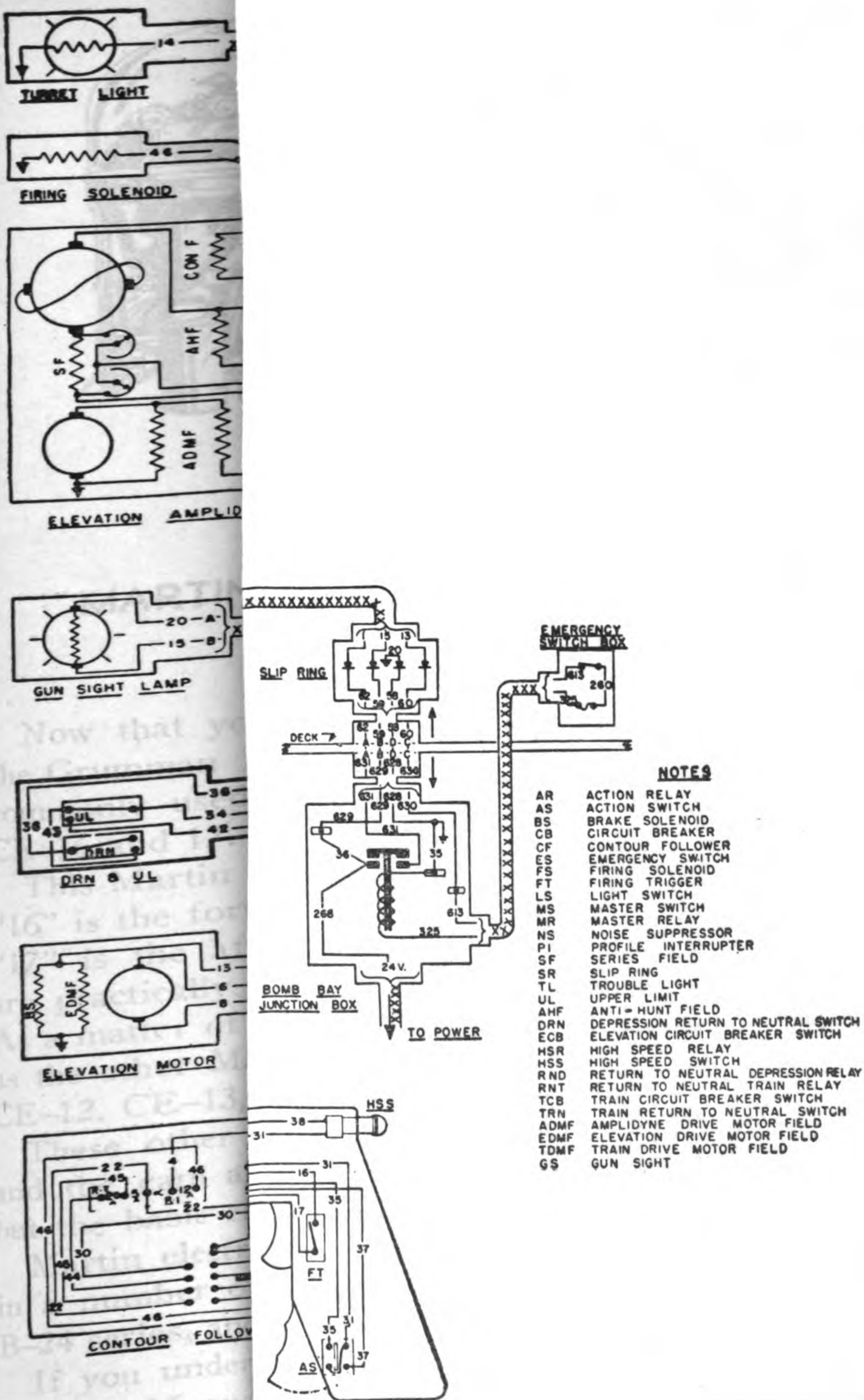
No deflection of controller

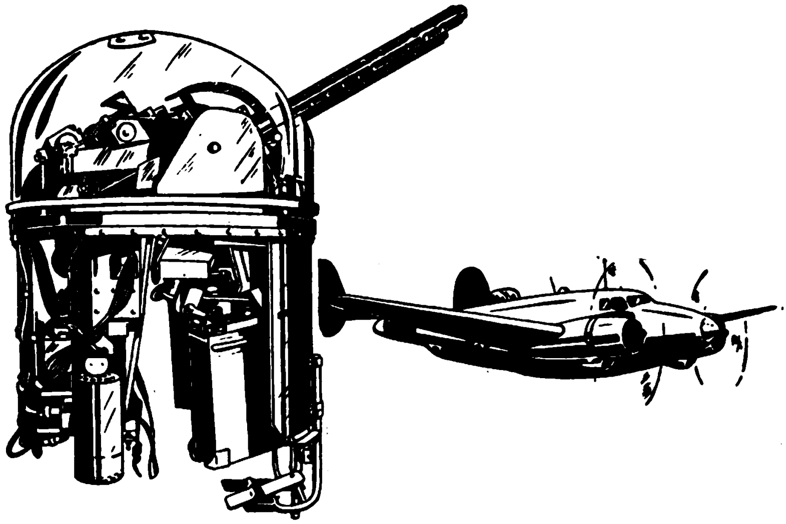
Mid-tap	Pot. arm
24	24

The normally closed RND contact between wires 5 and 8 is internally or externally shorted.

12	0

The RND normally open contact between wires 13 and 8 is not closing. Wire 13 is open, feeding normally open RND contact.


TURRET LIGHT
FIRING SOLENOID
CON F
AHF
SF
ADMF
ELEVATION AMPLID
GUN SIGHT LAMP
SLIP RING
EMERGENCY SWITCH BOX
DECK
DRN & UL
UL
DRN
ELEVATION MOTOR
EDMF
BOMB BAY JUNCTION BOX
24 V.
TO POWER
HSS
FT
AS
CONTOUR FOLLOW
NOTES
AR ACTION RELAY
AS ACTION SWITCH
BS BRAKE SOLENOID
CB CIRCUIT BREAKER
CF CONTOUR FOLLOWER
ES EMERGENCY SWITCH
FS FIRING SOLENOID
FT FIRING TRIGGER
LS LIGHT SWITCH
MS MASTER SWITCH
MR MASTER RELAY
NS NOISE SUPPRESSOR
PI PROFILE INTERRUPTER
SF SERIES FIELD
SR SLIP RING
TL TROUBLE LIGHT
UL UPPER LIMIT
AHF ANTI-HUNT FIELD
DRN DEPRESSION RETURN TO NEUTRAL SWITCH
ECB ELEVATION CIRCUIT BREAKER SWITCH
HSR HIGH SPEED RELAY
HSS HIGH SPEED SWITCH
RND RETURN TO NEUTRAL DEPRESSION RELAY
RNT RETURN TO NEUTRAL TRAIN RELAY
TCB TRAIN CIRCUIT BREAKER SWITCH
TRN TRAIN RETURN TO NEUTRAL SWITCH
ADMF AMPLIDYNE DRIVE MOTOR FIELD
EDMF ELEVATION DRIVE MOTOR FIELD
TDMF TRAIN DRIVE MOTOR FIELD
GS GUN SIGHT



CHAPTER 4

MARTIN 250 CE–16 AND CE–17 TURRETS

THE PB4Y'S LINE OF DEFENSE

Now that you have become familiar with the operation of the Grumman 150 SE–2, you will want to learn about another commonly used Navy electric turret. This is the Martin 250 CE–16 and 17.

This Martin turret helps to defend the famous PB4Y–2. The "16" is the forward upper deck turret in the PB4Y–2, and the "17" is the aft upper deck turret. These two modifications are practically identical, so they will be considered together. As a matter of fact, the "16" and the "17" are amost the same as the other Martin 250 CE turrets, such as the CE–5, CE–7, CE–12, CE–13, and CE–15.

These other modifications differ as to certain armor plate and the cam arrangement in the profile gun fire interrupter, but the basic electrical system is the same in all of them.

Martin electric turrets are used in the PV–1 and PV–2 and in a number of Army planes, including the B–26 series, the B–24 series, and the B–37 series.

If you understand the Grumman 150 SE–2 and the Martin 250 CE–16 and 17, you can consider yourself an AUTHORITY on Navy electric turrets.

WHAT MAKES THE MARTIN TICK?

As with the Grumman, the Martin CE turret drive consists basically of a CONTROL UNIT, two AMPLIDYNES, and two ELECTRIC MOTORS.

The turret obtains its power from the airplane's own generator. Power is taken in from a silver-plated copper COLLECTOR RING mounted on the inner side of an azimuth ring gear by insulated bolts. Then the power goes from the ring to the moving part of the turret through brushes. From there, power is transmitted to the various individual units.

What happens when the power gives out? Fortunately, provision has been made for this emergency. The turret may be operated mechanically in both train and elevation. There are cranks for this purpose. The guns may be charged by hand and, as you know, a machine gun will fire mechanically.

INDIVIDUAL ELECTRICAL UNIT

Many of the electrical units on the Martin are practically the same as those used on the Grumman, which you already know about. Therefore, all you will be doing in the rest of this chapter is reviewing and remembering the Grumman material and learning about any DISTINCTIVE FEATURES of the Martin.

The AMPLIDYNES on the Martin turret are exactly the same as those used on the Grumman.

The DRIVE MOTORS are very similar, except that they do not have a brake solenoid.

Now comes the CONTROL UNIT. This unit, by means of control grips, permits you to move the turret in azimuth and to control the movement of the guns in elevation.

When the control grips are deflected DOWN, the guns will move UP, and vice versa. When you move the control handles CLOCKWISE, the turret revolves clockwise, and when you move them in the opposite didrection, the turret will revolve the same way.

The Martin may be rotated through 360 degrees in either direction in azimuth. In elevation, it will boost the guns 85 degrees above horizontal and depress them six and a half degrees below horizontal.

The turret will make one revolution in 18 seconds in normal speed and in eight seconds in high speed. And that EXTRA SPEED counts when you have a half dozen enemies swarming in on you.

To understand the layout and arrangement of the control unit, look over figure 79 for a minute.

Now that you've seen figure 79, you can begin to analyze the functions of the important parts that make it up.

THE BIG BRAIN

This control unit is the real BRAIN, or NERVE CENTER, of the Martin turret. Impulses originating from this central point

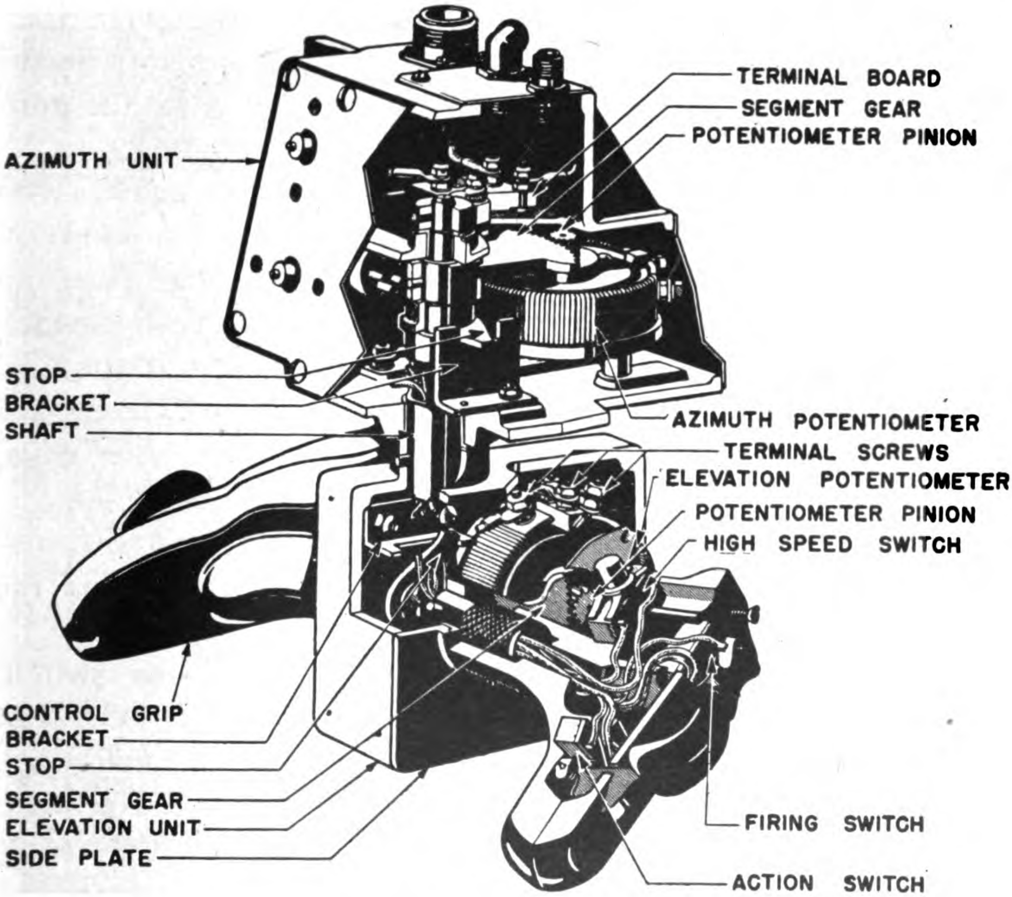


Figure 79.—Control unit.

determine everything the turret does, just the way YOUR brain and nervous system control YOUR movements.

When you grasp the grip handles of the control unit, you depress an ACTION SWITCH on each grip. These switches energize the potentiometer coils, located in the unit itself.

Now what happens? As you move the grip handles to direct the action of the turret, they cause sliding POINTERS to pick off voltages from the two potentiometers (one for train and one for elevation).

The polarity and magnitude of the voltages are applied to the amplidynes, which in turn, supply power to the TDM's.

When you want high speed, you press with your thumb the HIGH SPEED BUTTON, located on the right hand grip.

If you want to talk with a fellow crew member, you press a microphone switch on the left hand grip in the same corresponding position.

How DO YOU FIRE THE GUNS? First, turn the gun switch (on the right of the control box) to "ON." There is a selector switch beside the gun switch which permits you to set the guns for individual or collective fire.

You can reach a trigger switch on each grip handle with your index finger. If you set the selector switch on "INDIVIDUAL," your right trigger switch fires your right hand gun, and the left switch fires the left gun. If you set the selector switch on "BOTH GUNS," either firing trigger will fire both guns.

Additional switches and overload circuit-breaker resets are located on the control panel to protect the potentiometer coils, the ammunition booster circuit, and the firing circuit.

There is a JUNCTION BOX which serves as the CENTRAL DISTRIBUTION point for the electrical impulses originating in the control unit. It is under the gunner's seat.

This is what it contains. First, there's the master switch, on the right side of the box. A TERMINAL BOARD is located in the center of the box. It carries incoming electrical connections to the high-speed relay and the FBVR resistors. The LINE CONTACTOR relay is mounted inside the box, and next to it are two ANTI-HUNT CAPACITORS. Below them are four enameled RESISTORS, which are necessary for making speed adjustments by providing a path for the feedback voltage.

The HIGH-SPEED RELAY is mounted on the same bracket as the capacitors.

Also in the junction box you'll find the VIBRATOR INVERTER.

whose purpose you'll learn about later in this chapter. There's also a RADIO NOISE FILTER, to keep down radio interference (similar to the one on your car), and two overload circuit breakers to protect the amplidynes.

The STRUCTURAL INTERRUPTER AND LIMIT SWITCHES are electrical devices found on the Martin turret to protect your

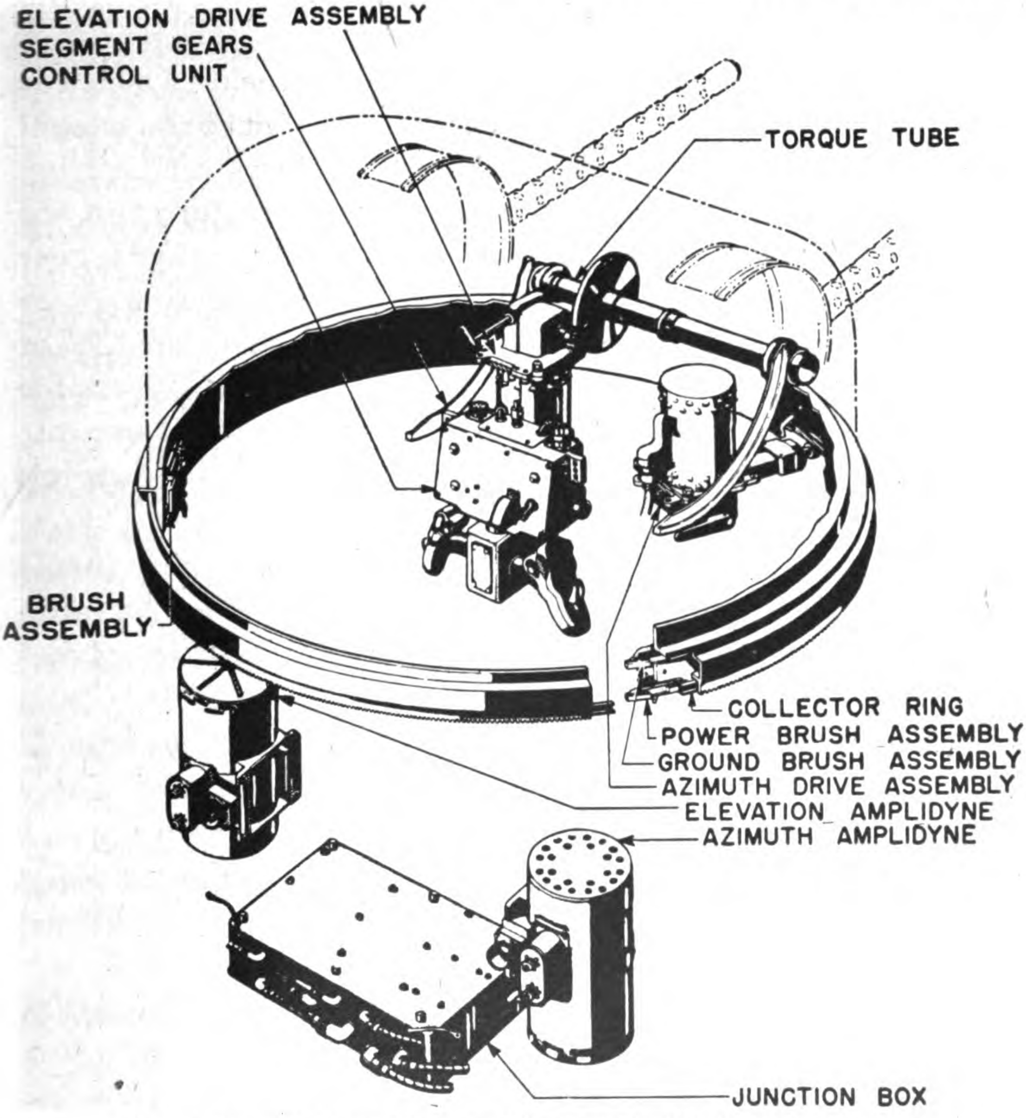


Figure 80.—Units making up Martin 250 CE–16 and 17 turret.

airplane from damage, either from your own gunfire or the motion of the guns. Exactly how they work will be explained with schematics when you come to the auxiliary circuits a few pages farther along.

The Martin also has a profile gunfire interrupter which works similarly to the one on the Grumman.

Just as in the electrical units, there are a few mechanical features of the Martin which you haven't come across in previous discussions on the Grumman or on turrets in general.

There's a MOUNTING RING which comes right with the aircraft. Strictly speaking, it's part of the airplane rather than part of the turret. The turret is mounted in this ring.

The AZIMUTH RING GEAR is the steel ring about which the turret revolves in azimuth. The load rollers, carrying the weight of the turret, ride on the upper part of the track of the ring. Then there are guide rollers which help keep the turret in the groove by riding against the vertical track. The ring's gear teeth are machined into the lower sides of the steel ring.

As far as TURRET ROLLERS are concerned, there are 26 of them — 10 load rollers, 12 guide rollers, and four adjustable stabilizer rollers for good measure. All of them follow separate tracks. The stabilizer rollers keep the turret from joggling up and down as it rotates.

The turret's MAIN CASTING is a rotating frame which forms the support for the turret parts. Attached to it is the azimuth TDM, which, by meshing with the azimuth ring gear, causes the casting to rotate.

The TORQUE TUBE is mounted in the bearing housings of the main casting. It transmits power from the elevation drive motors to the segment gears, which raise and lower the guns.

SEGMENT GEARS located on the outside of each gun carriage mesh with the small driving gears on the torque tube and afford movement of the gun in elevation and depression.

You know what the GUN CARRIAGE is — it's fastened to the main casting and mounts the BAM's.

Three steel eye-bolts known as HOISTING LUGS are fastened to the main casting for hoisting the turret in and out of the airplane.

There is a small metal COMMUNICATIONS AND OXYGEN JUNCTION BOX above the azimuth amplidyne. This houses connections for the communications system and the gunner's oxygen supply.

The turret's SWIVEL JOINT is a collector ring assembly mounted to the airplane directly below the center of the turret. Through this come the communication and oxygen connections.

PLENTY OF ARMAMENT

You have figured out from the designation "250" that the Martin's WALLOP consists of TWO .50 caliber machine guns. For protection, there are two half-inch steel armor plates bolted to the main casting in front of the gunner.

Today, Martin turrets are equipped with the MARK 18 GUN SIGHT, a self-computing illuminated sight which can do practically everything but cook. When this sight is added to a turret, its designation includes the letter "a" or "A." For example, 250 CE–16*A*. The sight is mounted in a cradle — a semicircular aluminum casting attached with trunnion pins to the main casting. It connects to the gun carriage with tie rods, so the sight raises and depresses with the guns.

Four AMMUNITION BOXES carry 200 rounds each. The Martin is equipped with an automatic FEED BOOSTER, one unit for each gun. These consist of small electric motors, spring mounted, and equipped with sprockets which mesh with the ammunition belt. The boosters are controlled by varied tension on the amunition belt, energizing and deenergizing the motors through micro-switches.

Gun mount adapters and guides, which are part of the gun carriage assembly, permit movement of the gun necessary for adjusting for boresighting and for locking the gun in firing position after boresighting.

A feature of the gun assembly on the Martin turret is the addition of E5A shock dampeners. These take up the recoil of the guns and minimize the vibration resulting from firing.

Another armament feature of the Martin is the MECHANICAL FOOT TRIGGER. This is a pedal mounted on a bar above the foot rest. It is connected to the trigger motor by a series of levers, a pole rod, and a flexible cable. This is really for emergency use only — when you want to fire the gun mechanically in the event of power failure.

HOW THE MARTIN OPERATES

You will remember in the case of the Grumman 150 SE–2, that certain auxiliary circuits help to provide smooth operation of the turret. It's the same way with the Martin CE's.

So you can understand the purpose and operation of these circuits more easily, there are schematics of each of them in the following pages.

To save time and space, abbreviations will be used in the schematics and explanations. Here they are —

MS	Master switch.
LCR	Line contact relay.
Amp.	Amplidyne.
CF	Control field.
HS	High speed.
HSS	High speed switch.
AS	Action switch.
FBVR	Feedback voltage resistor.
TDM	Turret drive motor.
ADM	Amplidyne drive motor.
AHF	Anti-hunt field.
CR	Compounding resistor.
SF	Series field.
LLR	Lower limit resistor.
ULR	Upper limit resistor.
SI	Structural interrupter.
ULS	Upper limit switch.
LLS	Lower limit switch.

NORMAL OPERATION

You already know what normal operation means on other turrets, and it means the same thing on the Martin. It's when the gunner has full control of the speed and direction of the turret's movements.

YOU DO THIS	WHAT HAPPENS?
Close the MS.	Current flows through the MS, energizing the LCR. LCR contacts being closed places 24 v. potential on line 9, energizing both amp. drive motors and putting both amp. in operation.
Close AS. Deflect control grip as shown.	Current flows through both potentiometers. Current flows from a high potential to a low potential through CF's, driving turret in desired direction.

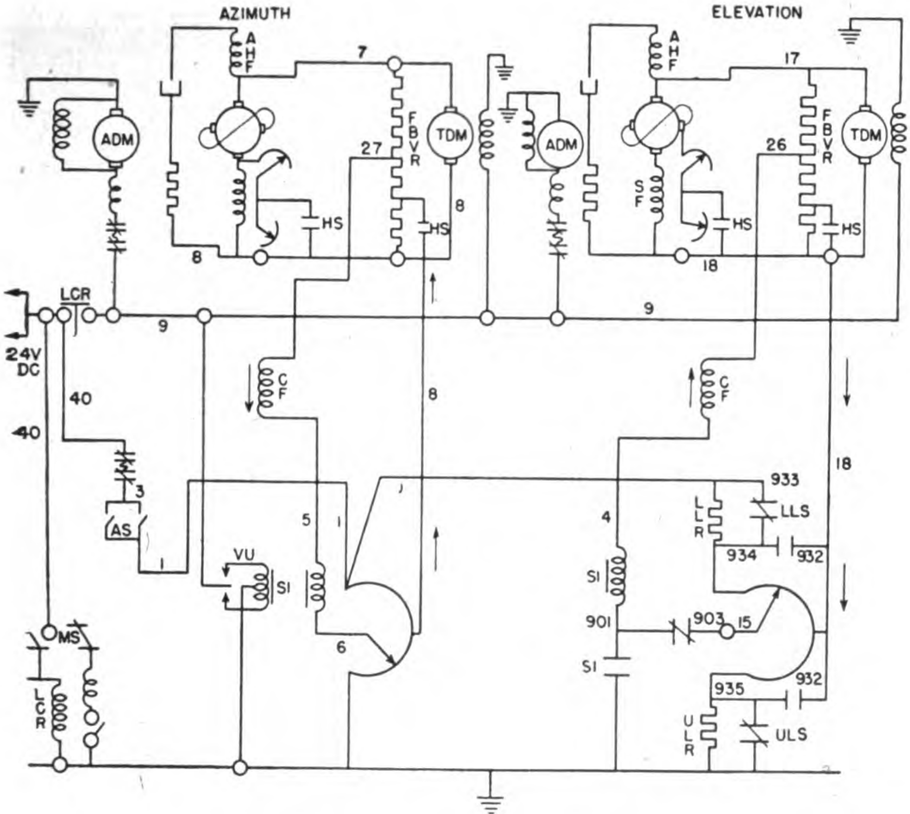


Figure 81.—Normal operation.

YOU DO THIS	WHAT HAPPENS?
Close MS and AS.	Turret is placed in normal operation.
Close HSS (energizing HS relay).	HS contacts close, decreasing the FBVR and also decreasing the resistance in parallel with series field (as shown).

USE OF VIBRATOR-INVERTER

Did you ever build a toy electric motor? At least, you've fooled around with them. You noticed how, when you turn on the juice, the motor is likely to buzz and strain, but it won't start. Then you give it a spin with your finger and AROUND IT GOES. It just needed that little extra push to overcome what's known as STARTING FRICTION.

Part of this friction is mechanical and part of it is electrical in origin. Once this initial drag is overcome and the motor starts turning, most of the effect of the friction disappears as the momentum increases.

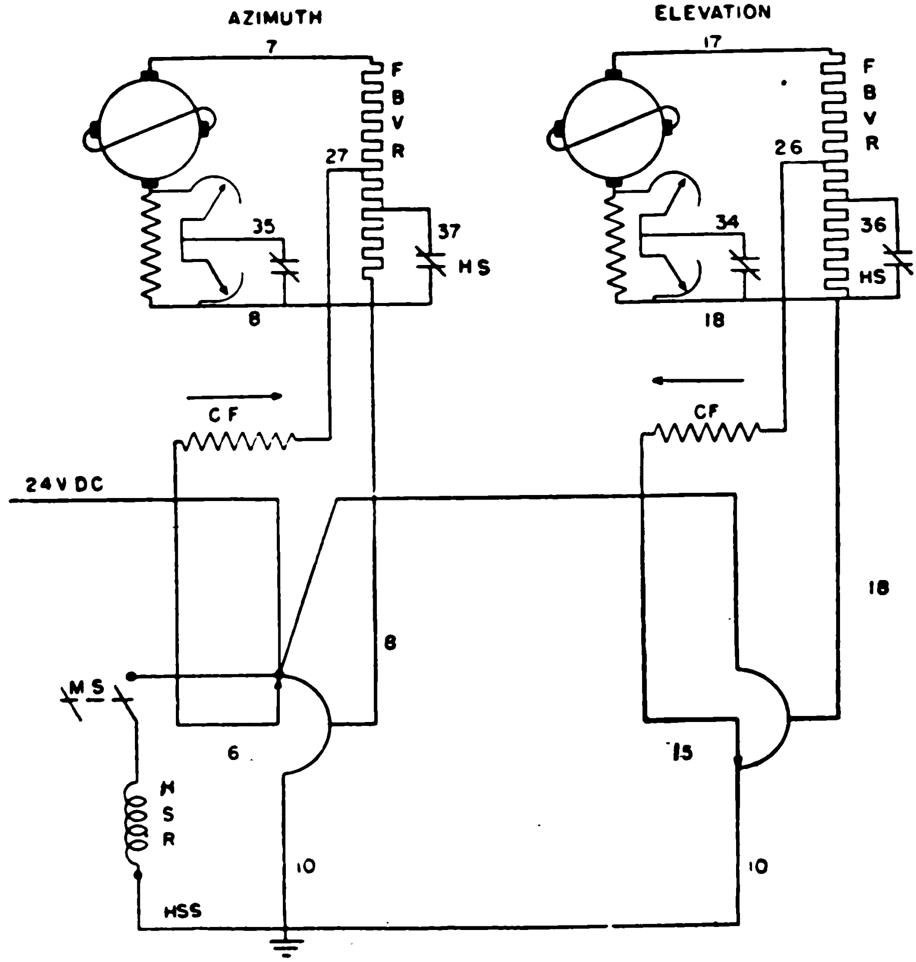


Figure 82.—Normal operation with HSS closed.

A turret, or any motor-driven equipment, reacts like your toy electric motor on a much bigger scale. The drag of friction will slow up the turret drive motors when you first feed electric current into them.

Moreover, a certain amount of "residual magnetism" — magnetism which stays on after the current is turned off — remains in the control field of an amplidyne. Sometimes there is enough of this magnetism to activate the amplidyne sufficiently so that the turret will begin to CREEP.

Now this is where the VIBRATOR-INVERTER comes in. Its purpose is twofold. It helps to lick that original friction drag which slows down starting in the TDM. And in addition, it eliminates the RESIDUAL MAGNETISM in the amplidynes, which can lead to creeping.

How does it accomplish this?

What the inverter does is change DIRECT current to ALTERNATING. The airplane's generators furnish d.c. of course, and this feeds into the primary winding of the inverter from line 9 (shown in the schematic in figure 83). A vibrator breaks and then closes the circuit alternately to secure alternating current. Then the current is fed through a step-down transformer

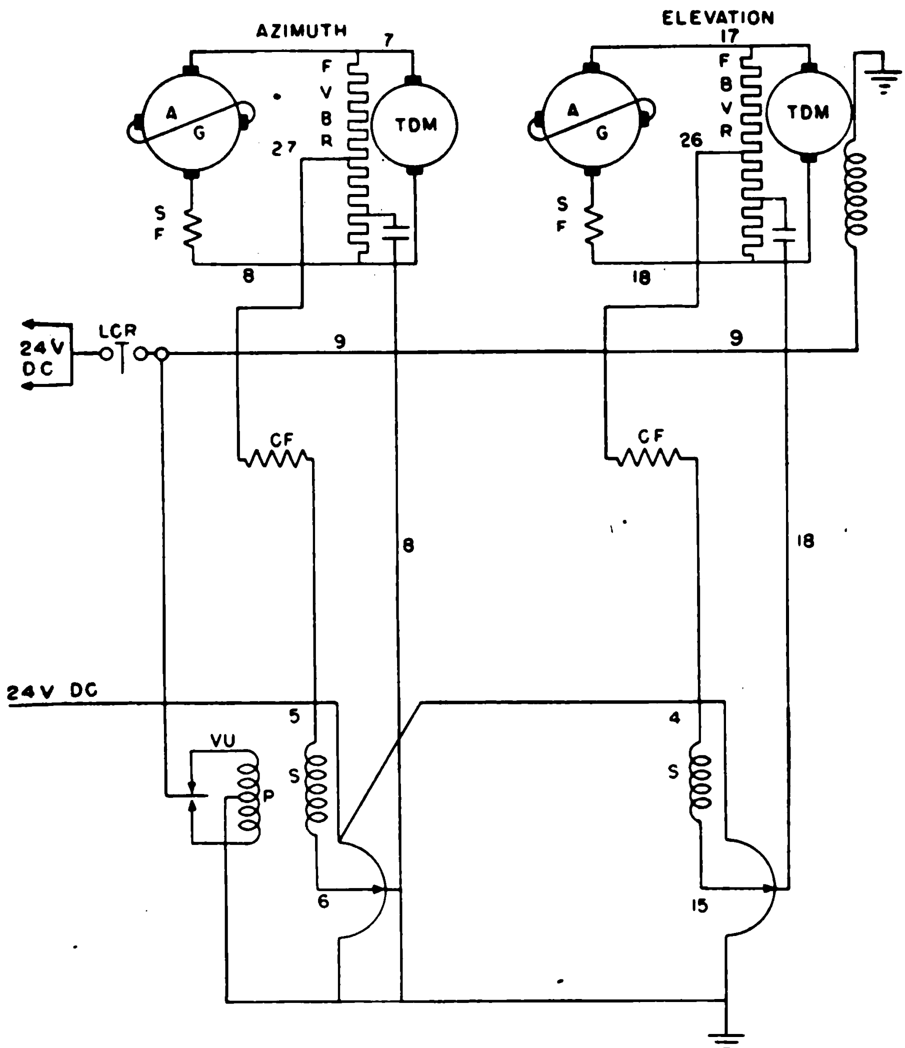


Figure 83.—Operation of the vibrator-inverter.

whose secondary winding is in series with the amplidyne control fields. It applies to proper voltage (16 v.) to the control field of the amplidyne.

This 60-cycle a.c. in the control field tends to stabilize generator commutation, eliminating residual magnetism. By its effect on the output of the amplidyne, it reduces the starting friction in the TDM.

Whenever the potentiometer arm is in the neutral position, there is no direct current flow in the control field circuit, because there is no difference in potential between the mid-tap voltage and the potentiometer arm voltage. At this point, the alternating current produced by the vibrator-inverter would be in this circuit.

Since the control field now has alternating current, the amplidyne also produces alternating current. This output, in turn, causes the turret drive motor to vibrate slightly.

Now when a voltage is impressed on the control field by deflecting the potentiometer arm in the desired direction, the turret drive motor has less starting friction because the motor is KEPT IN MOTION, however slight.

In the same manner, when the amplidyne is putting out its alternating current and then when a direct current voltage is impressed on the control field, the commutation of the generator would not be interrupted. This would tend to stabilize the generator commutation.

Whenever the turret is in operation and the control grip is deflected, the direct current from the potentiometer and the alternating current from the inverter combine. The resultant is a pulsating direct current. This has no specific effect on the turret operation. The inverter plays its important part when the direction of the turret is reversed or when the turret is started.

Only tiny split seconds are involved in this situation. The motors will start to turn WITHOUT any vibrator inverter. But the inverter helps to have those IMPORTANT FRACTIONS of seconds in starting — FRACTIONS of SECONDS which could mean the difference between bringing an enemy into your sight or letting him get away! That's what the vibrator-inverter amounts to.

SAVING THE SURFACES

The structural interrupter on the Martin accomplishes the same purpose as the contour follower on the Grumman. As you'll remember, this is to prevent the turret guns from hitting the fuselage as they move about.

Here's how it works. A cam engraved on the cylinder of the profile interrupter strikes a micro-switch. This causes a reversal of current flow through the control field of the amplidyne. This, in turn, reverses the direction of motion of the guns.

So the fuselage is protected every time the guns are about to connect with it.

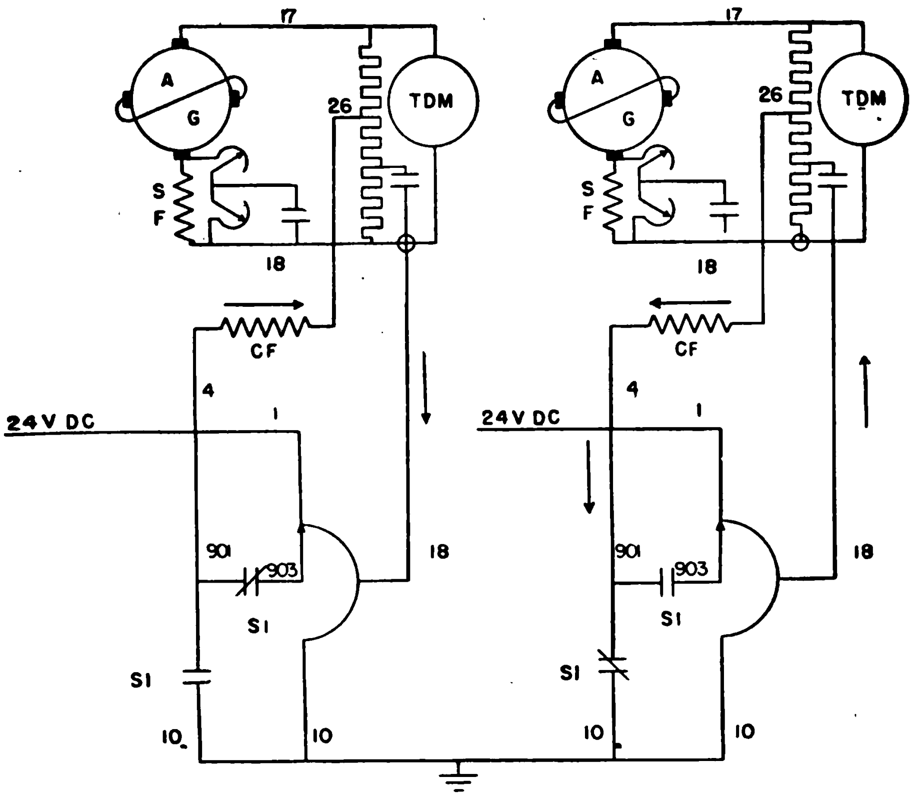


Figure 84.—Operation of the structural interrupter.

YOU DO THIS	WHAT HAPPENS?
With turret in operation, deflect control grip moving guns in depression.	Current flows through elevation control field from potentiometer arm to mid-tap (as shown).
Micro-switch actuated by cam.	Normally closed contact between 901 and 903 opens. Normally open contact between 901 and 10 (to ground) closes. Current reversed in control field. Flows from mid-tap to ground. Guns lifted off of structure.

WHAT THE LOWER LIMIT SWITCH DOES

Another insurance against damage to the airplane from the moving guns is the lower limit switch. How it works is shown in the schematic in figure 85.

In the Martin turret, when the guns are at right angles to the fuselage, they can be depressed six and a half degrees below the horizontal. To stop their motion before mechanical stops are engaged, a single pole, single throw micro-switch is inserted into the elevation potentiometer circuit.

When the limit switch is actuated by the cam located on the left segment gear, the normally closed contact opens. This puts a 30-ohm resistor in the circuit. The voltage drop across the resistor will be 12 v., since the normally open contact closes and shorts out the operating half of the potentiometer. This reduces the voltage on the control field to zero, and the guns stop where you want them to.

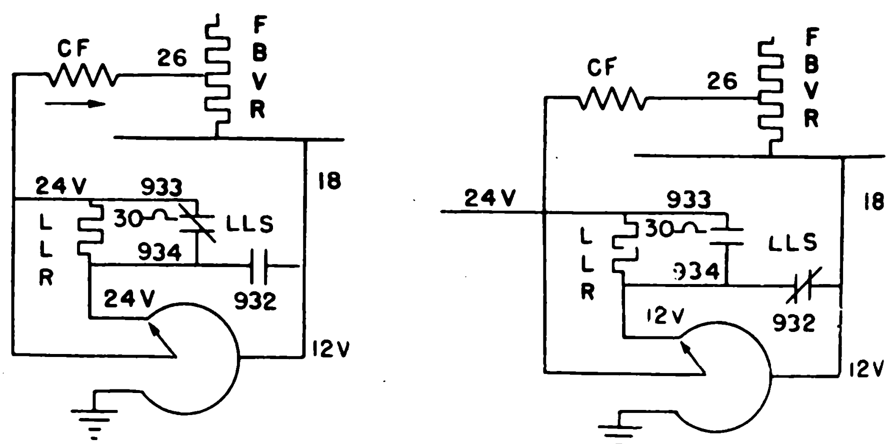


Figure 85.—Operation of the lower limit switch.

YOU DO THIS	WHAT HAPPENS?
Deflect control grip (as shown in figure 85).	Potentiometer arm on 24 v. potential. Current flows from arm through the control field to mid-tap. Guns depress.
Cam actuates lower limit switch.	Normally closed contact between 933 and 934 opens, inserting 30-ohm LLR in circuit. Normally open contact between 934 and 932 closes, shorting out half of potentiometer. Potential on arm and mid-top is now 12 v. Zero voltage on control field. Turret stops.

ONE MORE DAMAGE CONTROL PARTY

Still another control on the range of your guns is the upper limit switch. As you can guess, this is the opposite of the lower limit switch.

It prevents the guns from going beyond their limit in elevation, which is 85 degrees above the horizontal. This works on the same principle as the lower limit switch, as you can see by the schematic in figure 86.

A cam actuates the switch, the normally closed contact opens, and this puts a 30-ohm resistor in series with the potentiometer. The normally open contact closes, shorting out the operating half of the potentiometer. The turret stops.

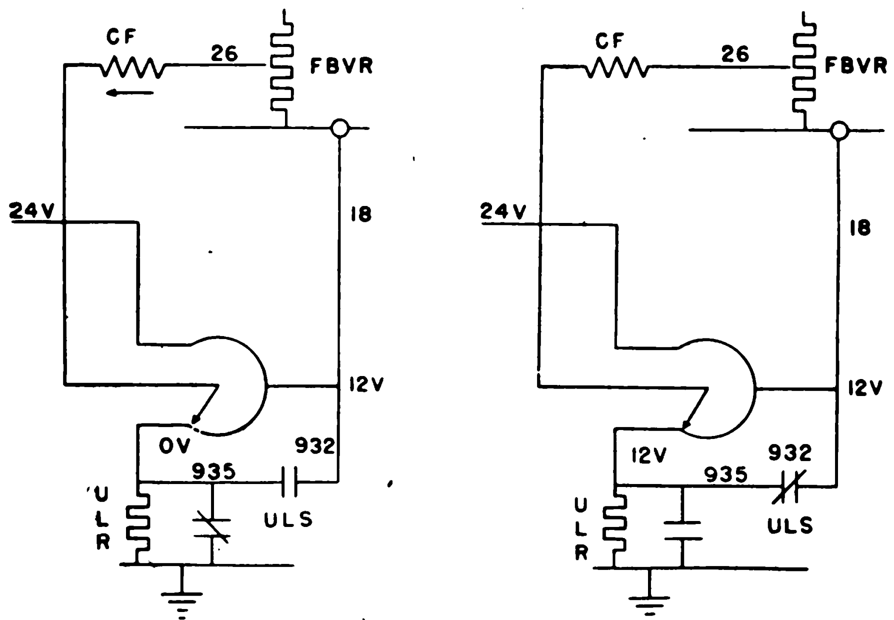


Figure 86.—Upper limit switch.

YOU DO THIS	WHAT HAPPENS?
Deflect control grip.	Potentiometer arm on zero potential. Guns elevate. Cam actuates upper limit switch. Normally closed contact between 935 and 10 opens, inserting 30-ohm ULR in circuit. Normally open contact between 935 and 932 closes, shorting out half of potentiometer. Potential on arm and mid-tap is now 12 v. Zero voltage on control field, turret stops.

TRACING TROUBLE—STEP-BY-STEP

Things being what they are, you just can't duck trouble all the time — even in the maintenance of the Martin electric turret.

You'll find the information in the rest of this chapter helpful in emergencies when the Martin turret fails to function properly.

To make it easy for you, this procedure has been streamlined. However, you'd better follow it STEP BY STEP in the right order, or you'll probably waste some time.

First of all, take a look at the schematic of the Martin 250 CE–16 and 17 in figure 87. It summarizes all the Martin circuits that you are familiar with by now. The designations on this schematic tie in with the references in the trouble shooting procedure discussion which follows.

One big help in trouble shooting is a little device you're already familiar with. It's the VOLTMETER. By showing you where the flow of voltage is either cut off or slowed down, the voltmeter will help you localize trouble in the circuit.

If you see that a ground or short is present when you're checking for trouble, shut off the power and use an ohmmeter instead of a voltmeter.

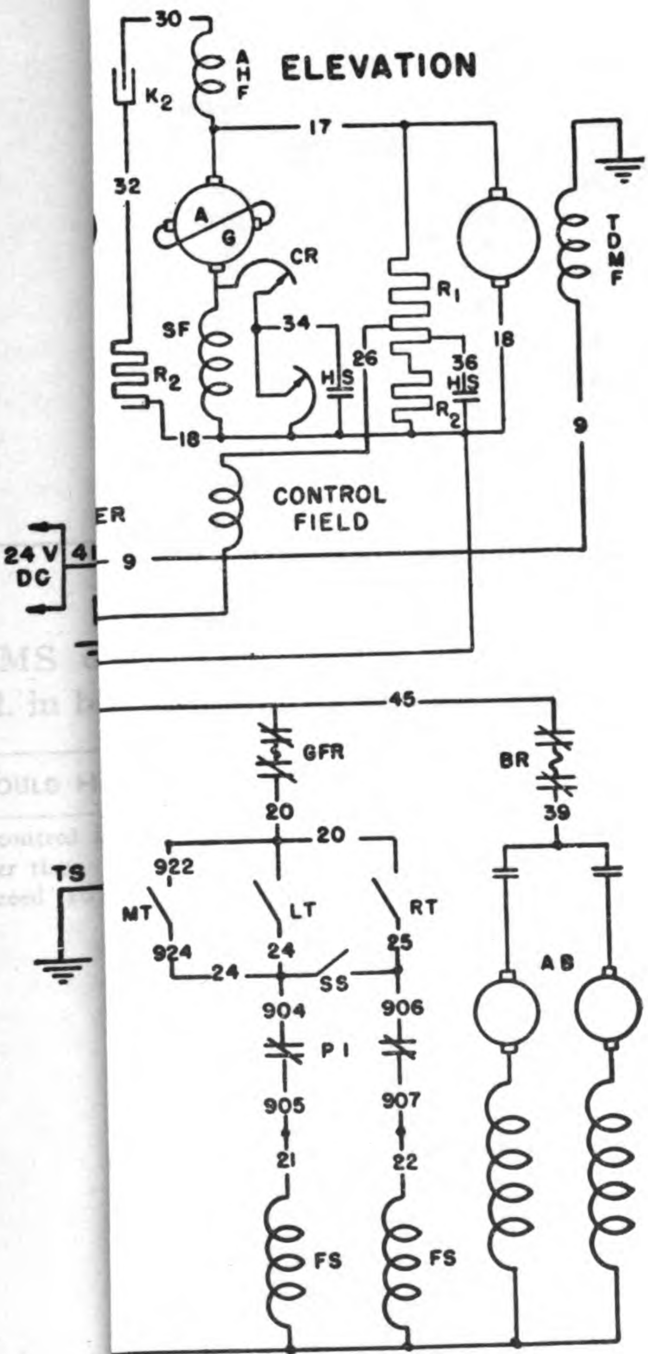
Incidentally, while this procedure is especially designed for the Martin CE–16 and 17, it may be applied to any Martin CE turret re-wired for continuous operation of the amplidynes.

FIRST STEP

Close MS switch — circuit now closed.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
LCR picks up and Az. and El. amp. operates without excessive sparking or vibration. Proceed to second step.	LCR fails to pick up.	Low source of voltage, or LCR circuit is open, or LCR is mechanically faulty.
	LCR chatters.	Low source of voltage, or resistance is being introduced into LCR circuit.
	Smoke is seen.	LCR is miswired, internally or externally shorted, or ADM circuit is grounded, or primary circuit of vibrator is grounded, or TDMF circuit is grounded, or sight light circuit is grounded.
	El. amp. motor does not run.	Open in El. ADM circuit after AR.
	Az. amp. motor does not run.	Open in Az. ADM circuit after ER or jumper between AR and ER.

WHAT SHOULD H



With MS
and in El. in

WHAT SHOULD H

Turret has control
and El. other th
speed. Proceed
steps.

WHAT SHOULD HAPPEN.	IF THIS HAPPENS	YOUR TROUBLE IS
	Neither of amp. motors run.	Open in LCR contacts, or open between LCR and CR.
	Az. amp. motor sparks excessively.	Az. amp. brushes are faulty, or Az. brush rigging is shifted from normal position.
	El. amp. motor sparks excessively.	El. amp. brushes are faulty, or El. brush rigging is shifted from normal position.
	Az. amp. CB kicks out.	Az. ADM circuit is grounded, or Az. amp. armature is frozen.
	El. amp. CB kicks out.	El. ADM circuit is grounded, or El. amp. armature is frozen.
	Az. amp. vibrates excessively.	Az. amp. bearings are faulty, or Az. amp. armature is unbalanced.

SECOND STEP

With MS closed, close AS. Deflect control grips in Az. and in El. in both directions.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
Turret has control in AZ. and El. other than proper speed. Proceed to third step.	No control in AZ. but amp. does not sound overloaded.	If turret does not hunt, refer to figure 88, page 127, and check as indicated, or if turret hunts, open in anti-hunt circuit, or amp. too badly over-compounded or open in control field circuit; refer to figure 88, page 127, and check as indicated.
	No control in El. but amp. does not sound overloaded.	If turret does not hunt, refer to figure 89, and check as indicated, or if turret hunts, open in anti-hunt circuit, or amp. too badly over-compounded, or open in control field circuit; refer to figure 89, page 129, and check as indicated.
	Az. amp. sounds overloaded.	TDM field is open, or TDM armature is internally or externally shorted, or TDM armature is frozen.

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WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
	El. amp. sounds overloaded.	TDM field is open, or TDM armature is internally or externally shorted, or TDM armature is frozen.

THIRD STEP

With turret in operation, fully deflect control grip in Az. and clock speed of turret (HSS is not actuated).

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
Turret should make one revolution in 18 seconds. Proceed to fourth step.	Takes turret more than 18 seconds to make one revolution.	Too much FBVR, refer to sixth step.
	Turret makes one revolution in less than 18 seconds.	Not enough FBVR, or open above control field tap in FBVR circuit, or HS relay is energized.

FOURTH STEP

With turret in operation, fully deflect control grip in Az. and clock speed of turret with HSS closed.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
Turret makes one revolution in 8 seconds. Go to fifth step.	Takes turret more than 8 seconds to make one revolution.	Too much FBVR when HSS is closed, or amp. under-compounded in HSS. NOTE: Any change made on HS compounding resistor will affect normal compounding.
	Turret makes one revolution in less than 8 seconds.	Not enough FBVR between control field tap and HS tap.
	Turret speed does not change when HSS is closed.	HS relay is not being energized when HSS is closed, or HSR contacts are faulty, or wire is open feeding HSR contact.
	Turret stops or almost stops when HSS is closed.	Not enough HS compounding resistance. NOTE: Any change made on HS compounding resistor will affect normal compounding.

FIFTH STEP

With turret in operation, close HSS and test compounding (use method described in chapter 2).

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
Turret neither speeds up nor slows down. Proceed to sixth step.	Turret speeds up under load.	Too much resistance in parallel with series field. (Adjust HS compounding resistor.)
	Turret slows down under load.	Not enough resistance in parallel with series field. (Adjust HS compounding resistance.)

SIXTH STEP

With turret in operation, deflect control grip slightly in Az., and test for compounding.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
Turret neither speeds up nor slows down. Proceed to seventh step.	Turret speeds up under load.	Too much resistance in parallel with series field. (Adjust normal compounding resistor.)
	Turret slows down under load.	Not enough resistance in parallel with series field. (Adjust normal compounding resistor.)

SEVENTH STEP

With turret in operation, close HSS and deflect control grip slightly in El., and test for compounding.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
Turret neither speeds up nor slows down. Proceed to eighth step.	Turret speeds up under load.	Too much resistance in parallel with series field. (Adjust HS compounding resistor.)
	Turret slows down under load.	Not enough resistance in parallel with series field.

EIGHTH STEP

With turret in operation, deflect control grip slightly in El., and test for compounding.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
Turret neither speeds up nor slows down. Proceed to ninth step.	Turret speeds up under load.	Too much resistance in parallel with series field. (Adjust normal compounding resistor.)
	Turret slows down under load.	Not enough resistance in parallel with series field. (Adjust normal compounding resistor.)

NINTH STEP

Take turret out of gear. Check output of vibrator inverter between terminals 2 and 4, and 5 and 6 with a.c. voltmeter, control grips in neutral position.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
Approximate output 8 to 16 volts a.c. Proceed to fifteenth step.	No output.	Open circuit feeding vibrator unit, or open circuit from vibrator unit to ground, or faulty vibrator unit (replace).
	Low output.	Faulty vibrator unit (replace).

TENTH STEP

Remove a drive motor cover and with turret out of gear and control grips in the neutral position, feel motor fan.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
Feel strong vibration.	No vibration.	Open circuit feeding vibrator unit, or open circuit from vibrator unit to ground, or faulty vibrator unit (replace).
	Little vibration.	Faulty vibrator unit (replace).

ELEVENTH STEP

Close AS. Connect VM across Az. CF and deflect control grip to full deflection. Close MS.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
VM reading should decrease to approximately .5 v. Proceed to thirteenth step.	VM reading increases.	Wires 37 and 5 are reversed, feeding control field, or wires 7 and 8 are reversed before FBVR.
	VM reading does not change.	Open in wire 7 feeding FBVR, or FBVR is open above control field tap, or amp. generator armature is open, or series field is shorted.
	VM reading decreases to approximately .1 v.	FBVR is open below control field tap, or too much FBVR.
	VM decreases to 0 v., then off scale.	Turret is over-compounded or there is too much FBVR.
	VM reading decreases slightly.	Series field is shorted, or short circuit wire is open, or faulty brushes, or faulty armature.
	VM reading decreases to approximately 2 v.	Anti-hunt condenser is internally or externally shorted, or short circuit wire is open, or series field is shorted, or faulty brushes, or faulty armature.
	VM reading decreases to approximately 1 v.	Not enough FBVR.

TWELFTH STEP

Close AS. Connect VM across El.' CF and deflect control grip to full deflection. Close MS.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
VM reading should decrease to approximately .5 v. Proceed to fourteenth step.	VM reading increases.	Wires 26 and 4 are reversed, or wires 17 and 18 are reversed before FBVR.
	VM reading does not change.	Wire 17 open feeding FBVR, or open in FBVR above control field tap, or amp. generator armature is open, or series field is shorted.
	VM reading decreases to approximately .1 v.	FBVR is open below control field tap, or there is too much FBVR.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
	VM reading decreases to 0 v., then off scale.	Turret is over-compounded, or too much FBVR.
	VM reading decreases slightly.	Series field is shorted, or short circuit wire is open, or faulty brushes, or faulty armature.
	VM reading decreases to approximately 2 v.	Anti-hunt condenser is internally or externally shorted, or series field is shorted, or short circuit wire is open, or faulty brushes, or faulty armature.
	VM reading decreases to approximately 1 v.	Not enough FBVR.

THIRTEENTH STEP

Place turret in operation and note exact symptoms.

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
	Turret operates reverse of control.	Wires 7 and 8 or 17 and 18 are reversed between FBVR and TDM armature.
	Turret speed is slow.	Anti-hunt condenser is shorted, or turret is under-compounded, or too much FBVR, or amplidyne brushes are bad, or amplidyne short circuit is open, or brush rigging is not adjusted properly.
	Turret creeps.	Turret is over-compounded, or Pot. arm is not at neutral position on Pot. coil.
	Turret speed is fast.	Not enough FBVR.
	Turret operates sluggishly.	Check vibrator unit. Refer to ninth step.

FOURTEENTH STEP

With turret in operation deflect control grip fully in elevation to elevate guns. At the same time, have another man actuate the upper limit switch. Caution: Be careful of fingers!

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
Turret stops. Proceed to fifteenth step.	Turret does not stop.	Open in wire 932, or open in ULR, or faulty switch.

FIFTEENTH STEP

With turret in operation, deflect control grip fully in elevation to lower guns, having another man actuate lower limit switch. Caution: Your assistant should watch his hand!

WHAT SHOULD HAPPEN	IF THIS HAPPENS	YOUR TROUBLE IS
Turret stops.	Turret does not stop.	Open in wire 932, or open in LLR, or faulty switch.

MORE VOLTAGE CHECKS

Now come some more voltage checks, similar to the ones you saw at the end of the chapter on the Grumman turret. With your voltmeter and these check readings, you can diagnose circuit headaches. The readings follow, and a wiring diagram for the Martin 250 CE–16 and 17 is shown in figure 92.

Open all switches. Remove wire 27 (control field tap) from FBVR. Close AS. Make and record three mid-tap voltage

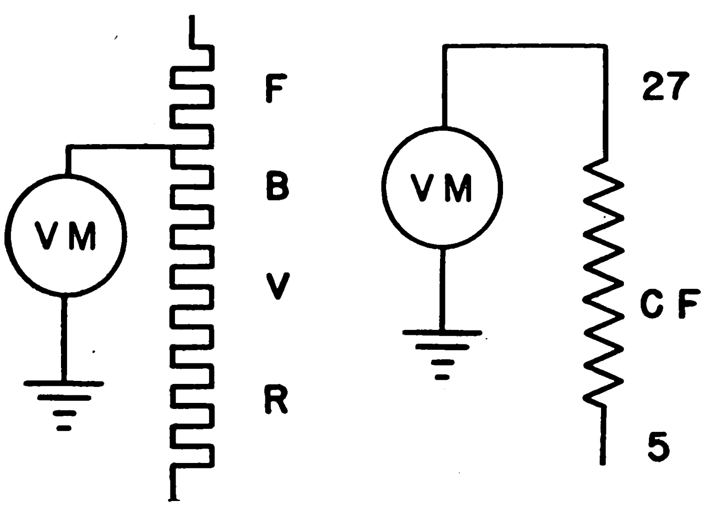


Figure 88.

checks by connecting VM to FBVR as shown. Then attach VM to wire 27 as shown and record the three potentiometer arm voltage checks. To find the fault compare voltage readings with those shown below.

First check with control grip in neutral position.		Deflect control grip to left.		Deflect control grip to right.	
Mid-tap	**Mid-tap**	**Mid-tap**	**Pot. Arm**	**Pot. Arm**	**Pot. Arm**
12	**12**	**12**	**12**	**12–0**	**12–24**

These are normal voltage checks. Proceed to figure 89.

0	**0**	**0**	**12**	**12–0**	**12–24**

Open in mid-tap circuit.

12	**12**	**12**	**0**	**0**	**0**

Open in Pot. arm circuit.

0	**0**	**0**	**0**	**0**	**0**

Open in line 1 feeding potentiometer.
Open in line 3 feeding AS.
Control reset blown.
Open in line 40.
Mid-tap and Pot. arm are both open.
Mid-tap is grounded and there is an open in Pot. arm.
Pot. arm is grounded and mid-tap circuit is open.
Faulty action switches.

24	**24**	**24**	**24**	**24**	**24**

Potentiometer coil is not grounded.

Mid-tap	Mid-tap	Mid-tap	Pot. Arm	Pot. Arm	Pot. Arm
24	**24**	**24**	**24**	**24–0**	**24**

Mid-tap circuit is receiving 24 v. due to a short.

12	**12–0**	**12–4**	**12**	**12**	**12**

Mid-tap and Pot. arm circuits are reversed.

0	**0**	**0**	**0**	**0**	**0–24**

Mid-tap circuit is grounded.

0	**0**	**0**	**0**	**0**	**VM jumps 0–24**

Azimuth Pot. coil is open above mid-tap.

24	**24**	**24**	**24**	**VM jumps 0–24**	**24**

Azimuth Pot. coil is open below mid-tap.

24	**24**	**24–12 (smoke)**	**24**	**24 (smoke)**	**24**

Pot. arm is shorted to 24 v.

0	**0–12**	**0 (smoke)**	**0**	**0**	**0 (smoke)**

Pot. arm circuit is grounded.

10	**10–12**	**10–12**	**10**	**10–0**	**10–24**

Anti-hunt circuit is grounded.

12	**12**	**12**	**Might be 12 or 0**	**VM reads uneven**	**VM reads uneven**

Pot. arm is not making good contact on coil.

12	**12**	**12**	**13**	**13–0**	**13–24**
12	**12**	**12**	**11**	**11–0**	**11–24**

Pot. arm is not at neutral position on coil.

Open all switches. Remove wire 26 (control field tap) from FBVR. Close AS. Make and record three mid-tap voltage checks by connecting VM to FBVR as shown. Then attach VM to 26 wire as shown. Record the three potentiometer arm voltage checks. Compare voltage readings with those shown below to find fault.

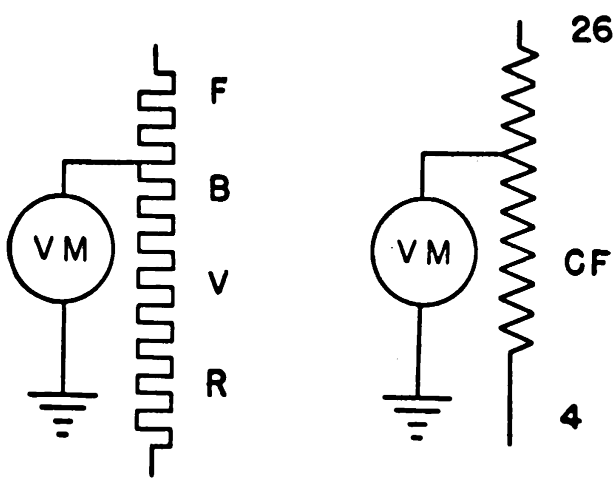


Figure 89.

First check with control grip in neutral position. Deflect control grip down. Deflect control grip up.

Mid-tap	Mid-tap	Mid-tap	Pot. Arm	Pot. Arm	Pot. Arm
12	12	12	12	12–0	12–24
These are normal voltage checks. Proceed to figure 90.					
0	0	0	12	12–0	12–24
Open in mid-tap circuit.					
12	12	12	0	0	0
Open in Pot. arm circuit. Structural interrupter switch is actuated or faulty.					
24	24	24	24	24	24
Potentiometer coil is not grounded.					
0	0	0	0	0	0
Open in line 28 feeding Pot. coil. Open in line 1. Open in line 3. Control reset is blown. Open in line 40. Faulty action switches.					
24	24	24	24	24–0	24
Mid-tap circuit is receiving 24 volts due to a short.					
12	12–0	12–24	12	12	12
Mid-tap and Pot. arm circuits are reversed.					
0	0	0 (smoke)	0	0	0–24
Mid-tap circuit is grounded.					
0	0	0	0	0	VM jumps 0–24
El. Pot. coil is open above mid-tap.					
24	24	24	24	VM jumps 24–0	24
El. Pot. coil is open below mid-tap.					
24	24	24–12 (smoke)	24	24 (smoke)	24
Pot. arm is shorted to 24 volts.					
10	0–12	0	0	0	0
Pot. arm is grounded.					

10	10–12	10–12	10	10–2	10–24

Anti-hunt circuit is grounded.

12	12	12	12	12–0	12

Lower limit switch is actuated.

12	12	12	12	12	12–24

Upper limit switch is actuated.

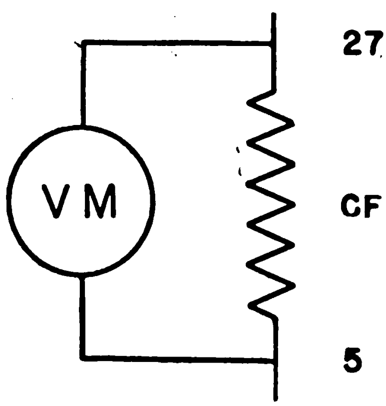
12	12	12	Might be 12 or 0	VM reads uneven	VM reads uneven

Pot. arm is not making good contact.

12	12	12	13	13–0	13–24
12	12	12	11	11–0	11–24

Pot. arm is not at neutral position.

Open MS and AS. Replace wire 27. Close AS. Check IR drop across CF with no deflection. Then check IR drop across Az. CF with full deflection to the left and then to the right. Record checks and compare with those shown below to find fault.



WIRE #27 ON FBVR
AND WIRE #5 ON
VIBRATOR UNIT

Figure 90.

No deflection of control grip.	Deflect control grip slowly to maximum left.	Deflect control grip slowly to maximum right.
VM reads	VM reads	VM reads
0	0 to approximately 4 v.	0 to approximately 4 v.

These are normal voltage checks. Continue with eleventh step.

0 0–12 0–12

FBVR is internally or externally shorted.

0 0 0

CF is internally or externally shorted.

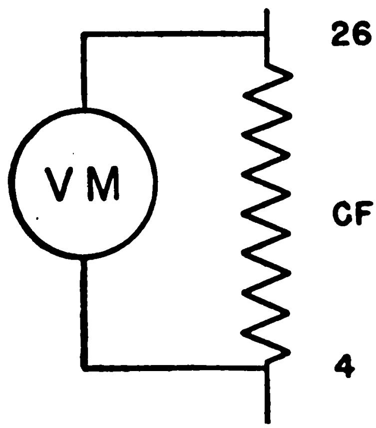
0 0–6 0–6

Not enough FBVR.

0 0–2 0–2

Go back to eleventh step and check as indicated there.

Open MS and AS. Replace wire 26. Close AS. Check IR drop across CF with no deflection. Then check IR drop across El. CF with full deflection to the left and then to the right. Record checks and compare with those shown below to find fault.



WIRE #26 ON FBVR AND WIRE #4 ON VIBRATOR UNIT

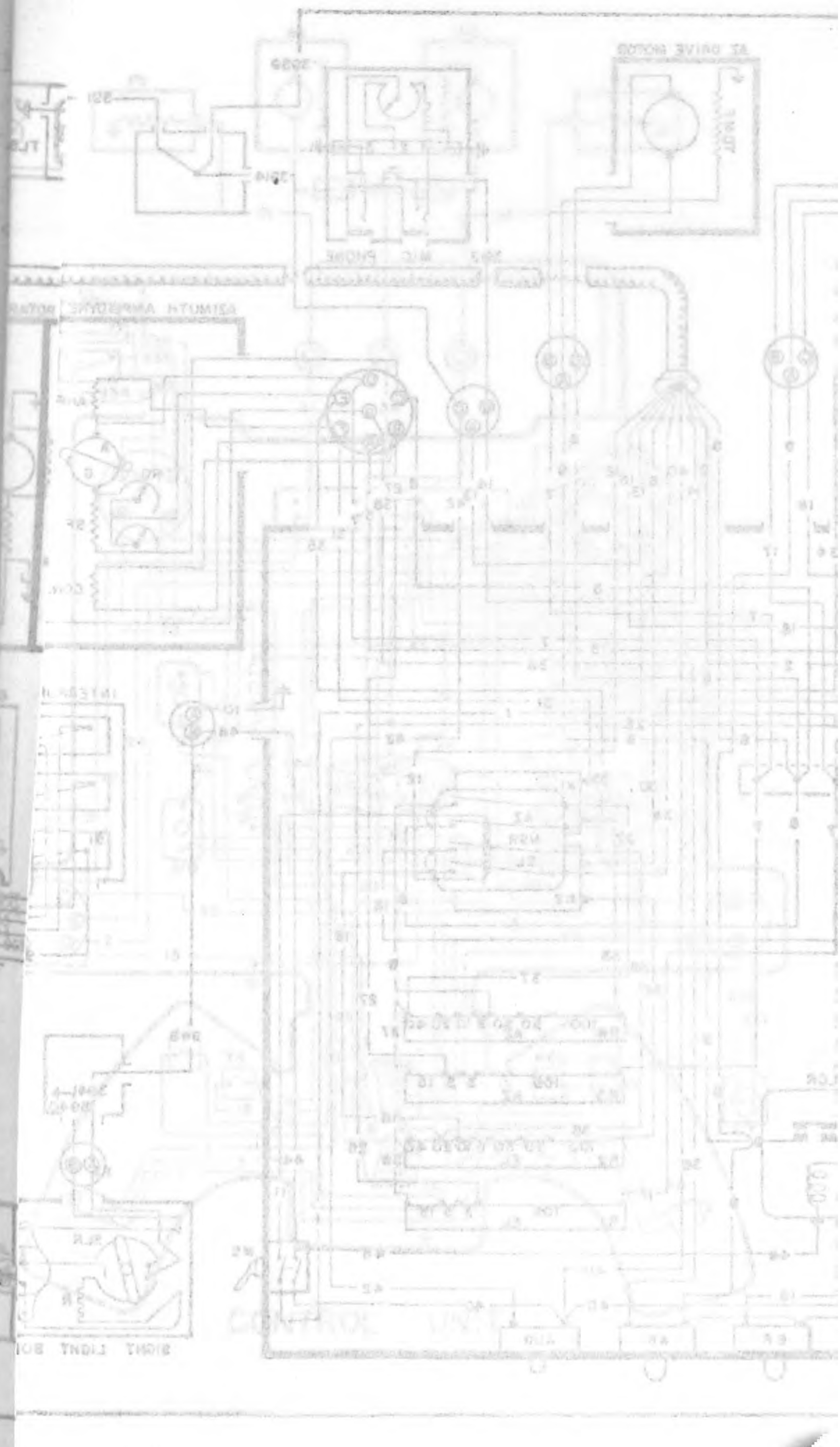
Figure 91.

No deflection of control grip.	Deflect control grip slowly to maximum left.	Deflect control grip slowly to maximum right.
VM reads	VM reads	VM reads
0	0 to approximately 4 v.	0 to approximately 4 v.

These are normal voltage checks. Continue with twelfth step and check as indicated.

0 0–12 0–12

FBVR is internally or externally shorted.



0	**0**	**0**

CF is internally or externally shorted.

0	**0 to approximately 6 v.**	**0 to approximately 6 v.**

Not enough FBVR.

0	**0–2**	**0–2**

Too much FBVR.

CHAPTER 5

HYDRAULIC TURRET SYSTEMS

PASCAL'S PRINCIPLE

Some 300 years before the first hydraulic turret, a clever French philosopher named Pascal hit upon a basic hydraulic principle. Pascal realized that AN INCREASE OF PRESSURE ON ANY PART OF A CONFINED LIQUID CAUSES AN EQUAL INCREASE IN PRESSURE THROUGHOUT THE LIQUID.

Now this means that when you apply a pressure in pounds per square inch (psi) to the liquid at one end of a pipe, the same pressure in pounds per square inch will be exerted on every square inch of the surface of the pipe that is in contact with the liquid. The shape of the pipe or other container makes no difference in the transfer of pressure.

You can see from this example that it is possible to build up ment of PASCAL'S PRINCIPLE. But you are more used to the term FORCE when speaking of applied loads.

WHY THE DISTINCTION?

Well, the term PRESSURE always refers to the force applied to EACH SQUARE UNIT of area, whereas the term FORCE is used to designate the TOTAL LOAD that is applied to the TOTAL AREA. This means that the force on a piston one square inch in area is also equal to the pressure on that piston. But the force on a piston ten square inches in area is ten times the pressure on that piston.

It is important that you realize and remember that hydraulic liquids are INCOMPRESSIBLE. This means that they CANNOT BE SQUEEZED into a smaller space than that originally occupied. Thus, when you apply pressure at one end of a hydraulic line, it is transmitted instantly to the other end. The transfer is as quick as though you had pushed on a steel rod.

So that you can see how hydraulics work, suppose you have a small cylinder and a large cylinder connected by a tube, as in figure 93. Both cylinders are full of liquid to within a short distance of the top. According to Pascal's principle, a force applied to each square inch of the liquid in the small cylinder is transferred undiminished to each square inch of surface of the liquid in the larger cylinder. Thus, the pressure applied to a small piston pushing down on the liquid in the small cylinder will be transferred through the liquid to a piston in the large cylinder. But, since the surface area of the large piston is greater than the surface area of the small piston, the sum of the unit forces acting on the large piston must be greater than the sum of the unit forces acting on the small piston.

For instance, if the area of the piston in the small cylinder is one square inch and the area of the piston in the large cylinder is ten square inches, a downward force of one pound on the small piston will cause an upward force of ten pounds on the large piston.

You will notice that the term PRESSURE was used in the state-tremendous forces by the application of relatively small initial forces. As a matter of fact, modern Naval aircraft make use of forces as high as 40,000 pounds.

Now take a look at figure 94. There you have a simple hydraulic mechanism. It is known as the hydraulic jack.

WHAT MAKES IT WORK?

If you push down on the handle, the oil is forced under pressure into the large cylinder. How come? Well, because the

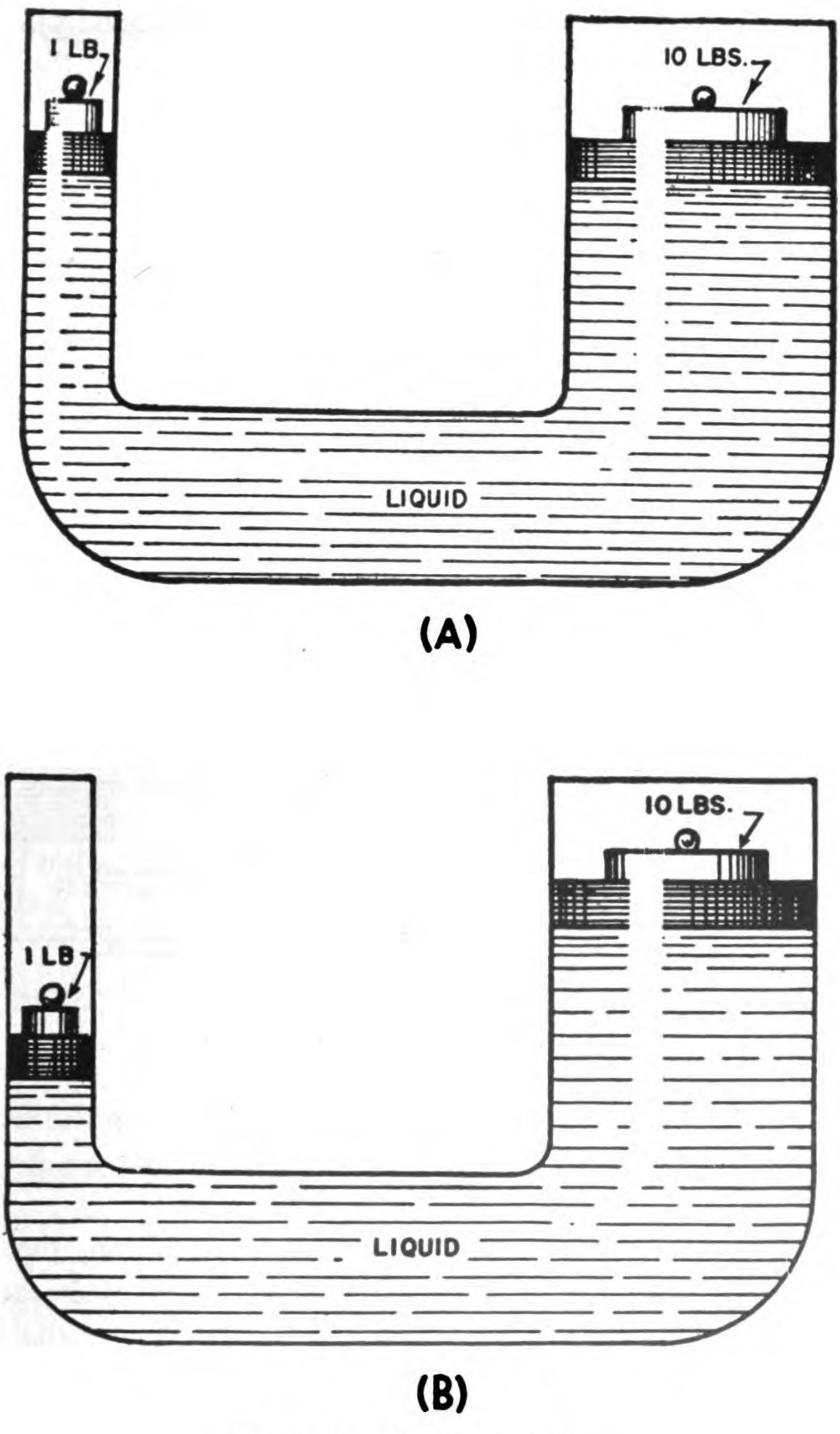


Figure 93.—Pascal's principle.

ball check valve is so designed that it permits the oil to flow only in one direction. The check valve to the cylinder is forced open, and the one between the pump and the reservoir closes.

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Then on the return, or UP STROKE, there is a decreased pressure area in the pumping cylinder, allowing the pressure in the large cylinder to seat that check valve.

However, because of the decreased pressure area in the pumping cylinder, the check valve in the line from the reservoir opens.

It is important here to understand WHAT opens that check valve.

The decreased pressure area or suction does NOT pull it down. A decreased pressure area is NOT the existence of a pulling force. IT IS THE LACK OF A PUSHING FORCE. Therefore, the ball check is NOT pulled open by decreased pressure, but rather it is PUSHED open by the greater oil pressure in the

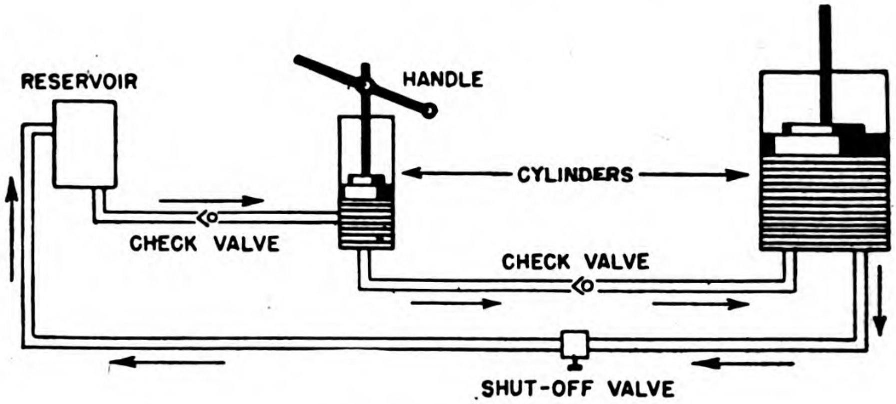

Figure 94.—Simple hydraulic system.

reservoir. The oil pressure in the reservoir is due to the weight of the liquid plus the atmospheric pressure acting on its surface through the vent lines.

When the pumping piston is in full UP position, the procedure is repeated again as many times as it is necessary to raise the large piston to its desired height. To lower the large piston, all you do is open the shut-off valve in the return line. This allows the oil a free flow back to the reservoir, and the return spring pushes the piston down.

Now that you understand the operation of a hydraulic jack, you can go on to investigate the various units that make up a turret hydraulic system.

And if you understand the operation and function of the individual units in a turret hydraulic system, then it will be easy for you to master the operation of any particular hydraulic turret. Just to give you a preview, here's a list of these basic units—

Reservoir	Pressure Regulator
Hydraulic Fluid	Selector (control) Valve
Hydraulic Lines	Power Actuating Units
Pump	

WHAT THE RESERVOIR DOES

You can start with the reservoir. You know what it is—a storage tank for fluid. It serves as a tank from which the fluid

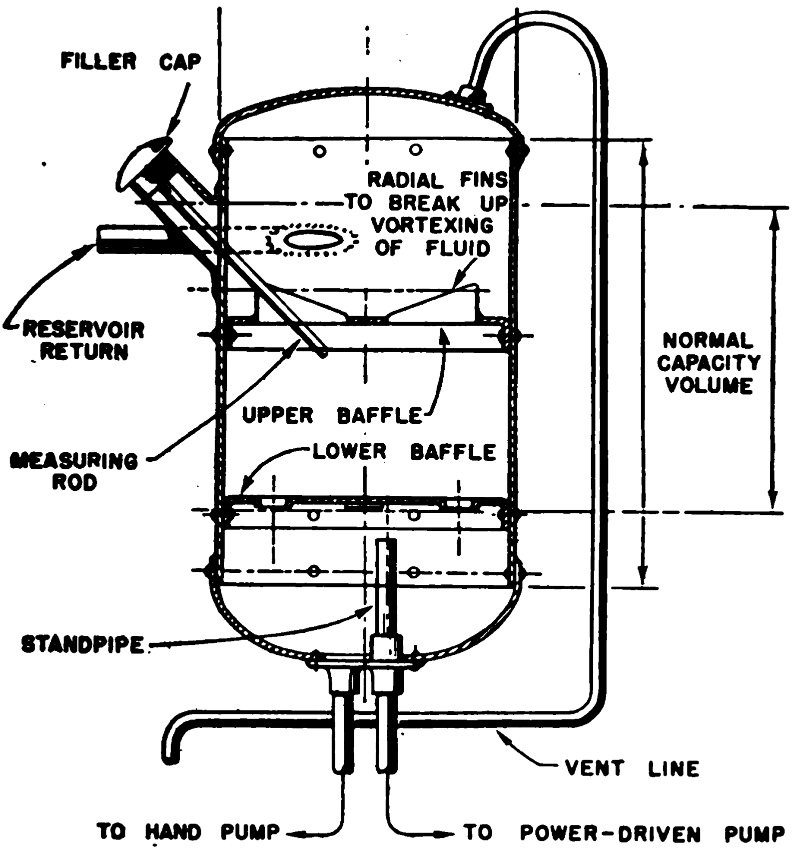

Figure 95.—Reservoir.

is supplied to the pumps and to which excess fluid forced out of the system is returned.

When additional fluid is needed in the system, either for operating additional units or to replenish fluid lost through leaks or seepage, the pump can draw that fluid from the reservoir. Furthermore, when increased temperatures cause the fluid to expand, the excess is delivered to the reservoir. The reservoir also provides a place where the fluid can settle and get rid of any air bubbles that have formed in the system. Foreign matter in the fluid is removed in the reservoir by filters, pumps, or similar devices.

Figure 95 shows you what a typical reservoir looks like. Notice that the VENT LINE rises from the top of the tank, runs down along the right side, and turns under the tank. This air line exposes the fluid in the reservoir to atmospheric pressure. Thus, a vacuum cannot form inside the reservoir, nor can air pressure build up.

Also it serves as a spill pipe for excess fluid that accumulates in the reservoir, and it allows the escape of any air that is carried into the reservoir from small trapped-air pockets in the lines and operating units.

KEEP THIS VENT CLEAN AT ALL TIMES.

Now look at the FILLER PIPE on the left-hand side of the drawing. Notice that it enters at a point considerably BELOW the top of the reservoir. This is to prevent over-filling and to provide a space above the fluid for expansion when the reservoir is filled to its normal level. Expansion results from increases in temperatures and from foaming of the liquid.

The filler cap is leaktight so that the fluid can't escape when the airplane is maneuvering or when the fluid expands. The measuring rod attached to the filler cap indicates the level of the fluid in the reservoir in much the same manner as the oil measuring stick in the crankcase of your automobile. Some reservoirs use a glass sight-gage instead of the measuring rod.

The BAFFLES and FINS inside the tank prevent excessive foaming or turbulence of the fluid when the fluid is flowing back from the return lines.

Now shift your glance to the STANDPIPE connected with the power-pump suction line at the bottom of the tank. Note that its inlet is a CONSIDERABLE DISTANCE ABOVE THE BOTTOM OF THE TANK—and for a good reason too!

This arrangement prevents the power pump from ever using up all the fluid in the tank. Thus, when the power pump ceases to function, there's still enough fluid available for the hand pump.

Instead of using a standpipe, some systems get the same results by attaching the power pump outlet to the side of the reservoir at a point above the bottom of the tank.

The FLUID RETURN LINE usually enters the reservoir at a spot below the normal level of the fluid in the reservoir in such a manner as to cause the least possible disturbance of the fluid. In figure 95, this is accomplished by attaching the return line at a tangent to the reservoir shell.

HYDRAULIC FLUID

This is the LIFEBLOOD of the hydraulic system. It starts in the reservoir and flows from there to fill the entire hydraulic system, furnishing the basis for transmitting hydraulic power.

There are different TYPES of hydraulic fluids just as there are different types of blood. Airplane systems use two kinds—MINERAL base and VEGETABLE base fluids

At present, turret systems use MINERAL BASE fluids.

When a wounded man is brought to a first aid station, the doctor doesn't look at him and say, "He looks like an 'O' type guy—let's give him a transfusion of 'O' type blood." Of course he doesn't. Giving a "B" man "O" blood is dangerous—AND a waste of blood. They just don't mix.

And NEITHER DO TWO TYPES OF HYDRAULIC FLUID. If you're working with a system which requires mineral base fluid, don't try to get by with a vegetable base fluid — even if you have a couple of spare tons of it.

There's a reason for not mixing these two types.

MINERAL OILS DETERIORATE NATURAL RUBBER the way week-end liberty deteriorates your bankroll. But natural rubber packing and natural rubber hose are not affected by vegetable base fluid.

It's another story with SYNTHETIC RUBBER. Mineral oil works fine with it, but VEGETABLE OILS RUIN IT. So use this rule—

VEGETABLE OIL FOR VEGETABLE (natural rubber) TUBING.

MINERAL OIL FOR MINERAL-TYPE (synthetic) TUBING.

How can you tell vegetable and mineral fluids apart? Aside from container labels, there's an easy way.

VEGETABLE FLUID IS COLORED BLUE.

MINERAL FLUID IS COLORED RED.

Just remember that red-blooded turret men prefer red mineral oil base fluid.

An aircraft hydraulic system, like the human body, is dependent on fluid for LIFE. A break in the feed line is like a severed artery. Both the human and hydraulic systems give up the ghost when life-giving fluid is allowed to drain out.

Even a little "bleeding" causes trouble. Turrets require transfusions, too. New fluid must be introduced into the system immediately to replace bleeding losses. And, of course, any breaks in the line must be repaired at once.

HYDRAULIC LINES

That brings you to the lines—the arteries and veins—which carry the fluid through the system.

They are metal tubes and rubber tubes, and they are joined by tube connectors and tube fittings of many shapes and sizes.

ALUMINUM ALLOY tubing is used in most turret systems because it is light and pliable and yet strong enough to withstand up to 1,500 psi.

SYNTHETIC RUBBER, along with fabric, is used where flexible hose construction is necessary. After natural rubber becomes available in larger quantities, it may be used. And, as you'll remember, that means vegetable oil base fluid will be used, too.

In a hydraulic system, various packings serve to seal fluid under pressure in the system and to keep air out. Wherever the various hydraulic units are connected to the hydraulic lines, you have DANGER SPOTS. Because this is where you will have moving parts, vibration, access ports (to get at the units), and so on.

So you'll watch these spots particularly to guard against fluid leaks and air getting into the hydraulic lines—two BIG HEADACHES which must be avoided if you're going to have smooth hydraulic operation.

THE HEART OF THE SYSTEM

If the hydraulic fluid is the lifeblood and the hydraulic lines are the arteries, the hydraulic pump could be considered the HEART of the system.

Two types of power-driven pumps are ordinarily used in hydraulic turret systems. They are VARIABLE DISPLACEMENT and CONSTANT DISPLACEMENT pumps. Sometimes they're called variable volume and constant volume.

The names of these two pumps give you a tip-off on how they differ. The variable displacement type puts out at a varying rate, depending on the volume requirements at a given time. The constant displacement job pumps at a constant rate—its capacity and volume are fixed.

There is another type of pump which comes with a turret, a HAND PUMP. This is really an emergency item, and cannot be considered one of the basic hydraulic units which you are

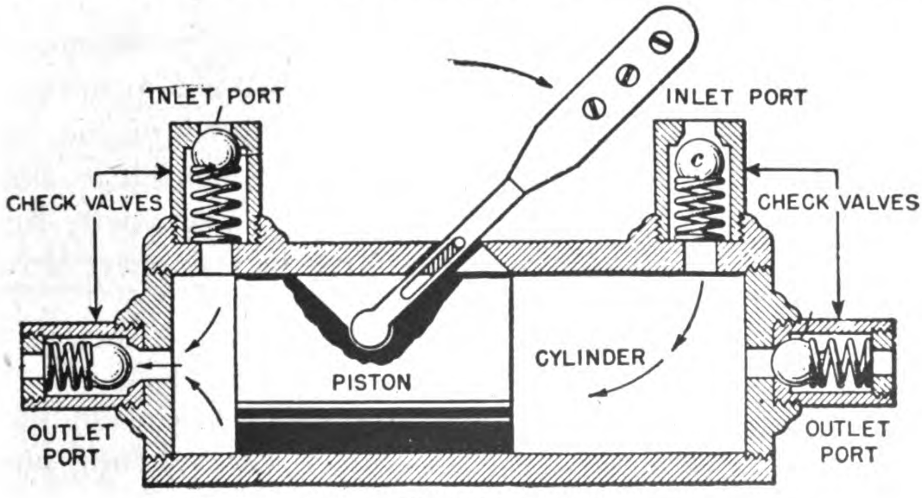

Figure 96.—Hand pump.

reading about now. In other words, this pump is designed to go to work when the power fails and the electrically-driven pumps quit on you.

It can also be used to check the hydraulic system when the engines of the airplane are not running and consequently you have no power.

One look at figure 96 and you can tell that the hand pump is really very simple in construction. It consists essentially of a cylinder having inlet and outlet ports, a piston, and a handle for operating the piston. Throw in a few necessary check valves, packings, and seals — and that's the works.

Here is how the pump operates.

You pull the handle toward the right, thereby moving the piston toward the left. The liquid in front of the piston (to the left of in the illustration) is forced out of the cylinder through the check valve of the outlet port. Meanwhile the piston is drawing in fluid through the inlet valve to the right. Then, when you pull the pump handle back toward the left, the piston moves to the right. Thus, liquid is forced out of the right-hand end of the cylinder while more liquid is flowing into the left-hand end.

The check valves in the inlet ports prevent the fluid in the pump from being forced back into the reservoir. The check valves in the outlet ports prevent the fluid in the system from being drawn back into the pump.

In well-designed hand-operated pumps, the area of the piston and the length of the handle are proportioned so that you can develop high pressures without working yourself to death.

The simplicity of construction and operation of the hand pump may lead you to believe that there isn't much to worry about in the way of service or maintenance. Well, you're right, there isn't. So suppose you move along to the power driven pump.

VICKERS PUMP

The Vickers VARIABLE DISPLACEMENT (or volume) pump is used on nearly all hydraulic turrets. It is ideally suited to turret operations since it is designed to produce constant pressure at a varying volume, depending on how much volume is required at a certain moment. When there is a greater demand for fluid in the system, the pressure tends to drop slightly. This is where the pump goes to work. It keeps the pressure up and supplies the necessary volume of fluid. If pressure is off just a fraction, then the pump will apply to the system just that fraction of pressure necessary to eliminate the deficiency. And it does all this AUTOMATICALLY.

In order to understand fully how a variable delivery pump operates, think about hydraulic pressure and the relationship between pressure and volume. Remember that no comparison can be made between air pressure and hydraulic pressure. Air can be compressed in suitable containers, and the pressure so stored can be used later. Hydraulic fluid, however, CANNOT BE COMPRESSED. And hydraulic pressure can't be stored, to be used as needed.

In order to obtain hydraulic pressure, a DRIVING FORCE is needed—something to "push" the fluid through the tubing. Such a driving force is the HYDRAULIC PUMP, which creates hydraulic pressure within the system by PUSHING the hydraulic fluid through the passages.

However, in order to have hydraulic pressure, there must be a RESISTANCE of some kind. If the outlet port of the hydraulic pump is connected to the inlet port by a long tube, the system filled with fluid, and the pump set in motion, NO PRESSURE WILL BE CREATED. The fluid will merely CIRCULATE slowly or rapidly, depending on the speed of the pump.

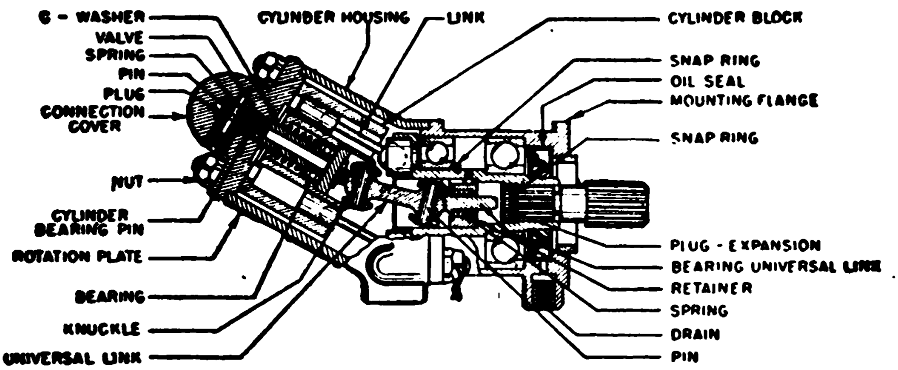

Figure 97.—Vickers piston pump.

But if a hydraulic motor is installed in the line, and a load put on the motor shaft, pressure will build up in the lines. Because the motor with its load will be offering a RESISTANCE to the flow of fluid, while more fluid is being PUSHED against it, pressure begins to form at the point where the resistance is located and backs up toward the source of power.

Volume is the MEASUREMENT OF FLUID FLOW. Pressure is the AMOUNT OF POWER available. Once operating pressure has been reached, practically no volume is required, except to make up for leakage losses. As soon as the operating pressure is put to work, more volume is required—but only enough to maintain the pressure, or push, behind the fluid that is doing the work. Operation is fully automatic since the variable delivery pump is designed to BUILD UP and MAINTAIN a pressure, thereby maintaining a balance between pressure and volume in an inverse ratio.

The CONSTANT DISPLACEMENT pump is used in the Motor Products Corporation's turret hydraulic system. Most of the internal mechanisms and all of the actual pumping system are the same in both of these Vickers pumps (variable and constant).

To get a peek at the inner workings of the Vickers constant displacement pump, see figure 97.

Things are getting a little more complicated, so you better take a good LONG look at this cross-sectional drawing. Note that the cylinder block is positioned at an angle to the driving mechanism.

There are seven cylinders spaced equally around the cylinder block axis, and the cylinder bores are parallel to that axis. The cylinder block is linked to the driving mechanism by a universal block so that the driving mechanism and cylinder block rotate at the same speed.

When the driving mechanism and cylinder block are rotated, the position of each piston in its cylinder is changed.

As this driving mechanism and the cylinder block are thus rotated about their axes and the pistons start their movement away from the cylinder head, a port in the cylinder head opens to allow fluid to be drawn into the cylinder.

When the piston reaches the bottom of its stroke, the discharge port is opened and fluid is forced from this port to the system by the upward motion of the piston. This cycle is repeated as each piston travels down, and then up, in its cylinder.

The variable displacement pump works in a similar way, EXCEPT that the angle of the cylinder block is VARIABLE. Thus, when more volume is required, the angle is increased to produce more output. When less volume is needed, the angle is decreased automatically.

PRESSURE REGULATOR

An important little gadget is built right into the variable displacement pump. It is called the COMPENSATING VALVE. On the MPC turrets, a device called a PRESSURE REGULATOR fulfills the same function as the compensating valve, so you can think of these two devices together. The compensating valve pivots a yoke on the pump and changes the stroke of the piston as required to meet the varying demands for volume. As its name suggests, the pressure regulator is a device for regulating the pressure in the system. It is placed between the power pump and the system so as to bypass the oil just as soon as the system pressure reaches the upper limit of the pressure range for which the regulator is adjusted.

When that pressure value is reached, a valve in the pressure regulator opens. The output of the power pump, which has until now been flowing into the system beyond the pressure regulator, can no longer pass the regulator and is shuttled from pump to reservoir, to pump, to reservoir, to pump, to reservoir.

This BYPASS CIRCUIT through the regulator continues until the pressure in the system reaches the lower limit of the range for which the regulator is adjusted. Then the valve closes, and the output of the pump is once more sent past the pressure regulator and on into the system.

The pressure regulator can be set to pass fluid into the system over a broad range of pressures.

Vickers pumps are power-driven, and the unit which does the driving is a small ELECTRIC MOTOR.

This electric motor turns an output shaft, using a reduction gear system.

This gear assembly consists of a bevel gear riveted to a steel shaft, which is mounted on two ball bearings. The motor assembly is installed on the hydraulic pump by means of the drilled machined face on the gear housing, through which the splined end of the output shaft is accessible. The motor, turning clockwise when viewed from the drive end, provides the power for turning the assembly. The external spline of the hydraulic pump, to which the motor is attached, fits into the internal spline of the gear shaft, and by this means the hydraulic pump is actuated.

The source of power to operate the electric motor comes right from the airplane's engine generator system or its auxiliary power plant.

SELECTOR VALVES

You now have the hydraulic fluid stored in a reservoir and then pumped through the system. But the flow must be DIRECTED to, the spot in the system where hydraulic pressure is to be used to perform a specific function at a specific time.

That job of directing is done by the SELECTOR VALVES. Hydraulic selector valves are the control switches—the steering wheel—of the aircraft hydraulic system. They are used to direct the flow of fluid to, or from, the desired unit in the system. Thus, they control the fluid's direction of motion, the amount of motion, and the speed. There is usually a selector valve for each hydraulically operated unit in the system.

This valve is commonly called a FOUR-WAY selector valve because it has four ports for connection with the system. There are such things as two-way, three-way, and five-way selector valves, but the four-way valves are most common in aircraft

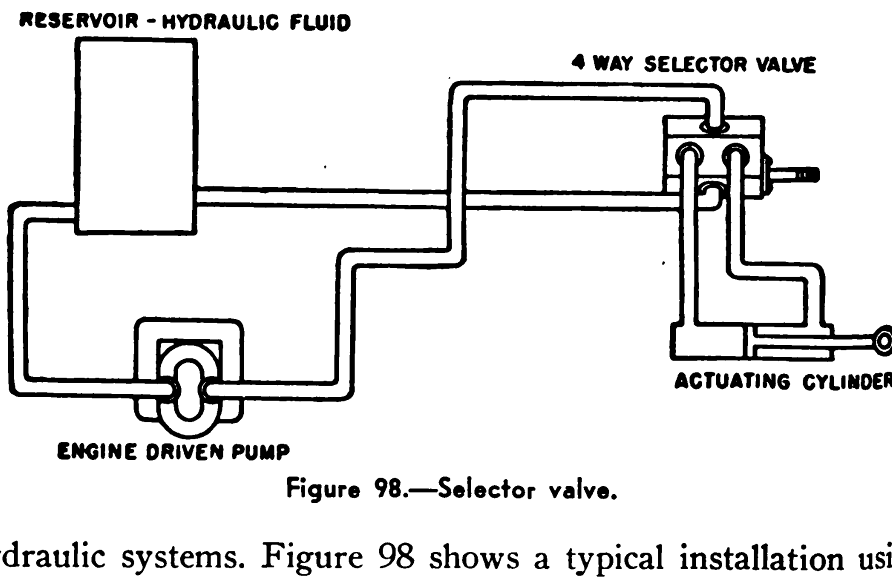

Figure 98.—Selector valve.

hydraulic systems. Figure 98 shows a typical installation using a selector valve to control the operation of an actuating cylinder in either direction.

Notice that a line from the pump enters the top of the selector valve housing while a return line to the reservoir is connected to the bottom. There is also a line extending to each end of the actuating cylinder. By turning the valve, it is possible to direct the fluid from the pressure line to either end of the actuating cylinder. Fluid is forced from the opposite end of the actuating cylinder by the motion of the piston. This fluid is forced through an opening in the selector valve and returns to the reservoir where it is ready to be used again.

CONTROL VALVES

The turret's speed and direction are controlled by a special type of selector valve connected to the control handles. Its set-up is similar to that sketched in figure 99.

From this basic diagram, the flow diagram of any valve-controlled turret can be constructed by making additions as

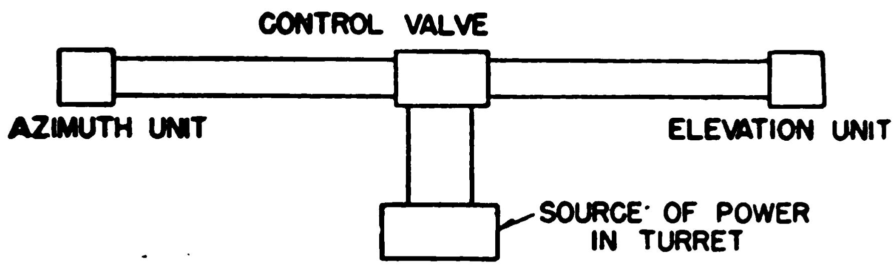

Figure 99.—Basic diagram, valve-controlled turret.

dictated by the hydraulic, mechanical, and structural requirements of the turret itself.

The source of power in the system diagrammed in figure 99 may be a Vickers variable displacement pump, or it may be a hydraulic swivel in the base of the turret which gets its supply of hydraulic power from an outside panel or from the airplane's main system. The control valve used in all turret hydraulic systems at present is the CLARKE VALVE.

Take a look at this valve and the control handles which operate the valve in figure 100. This arrangement OPERATES THE TURRET.

A Clarke control valve controls the direction and speed of the turret and contains the control handles, safety or "dead man" switches, and trigger switches.

The valve assembly consists of two four-way valves. Each is connected to and is controlled by the motions of the control handle.

The Clarke control valve takes the high pressure oil from the pump and valves it selectively in one of two directions in the ELEVATION and AZIMUTH SYSTEMS. In this way, movement of the control handle in any direction automatically regulates the flow to drive the proper (elevation or azimuth) CYLINDER in the corresponding direction. You'll find out how these cylinders work a few lines farther along.

The valve housing has six ports, two on the exterior surface and four on the bottom surface. The two ports on the exterior

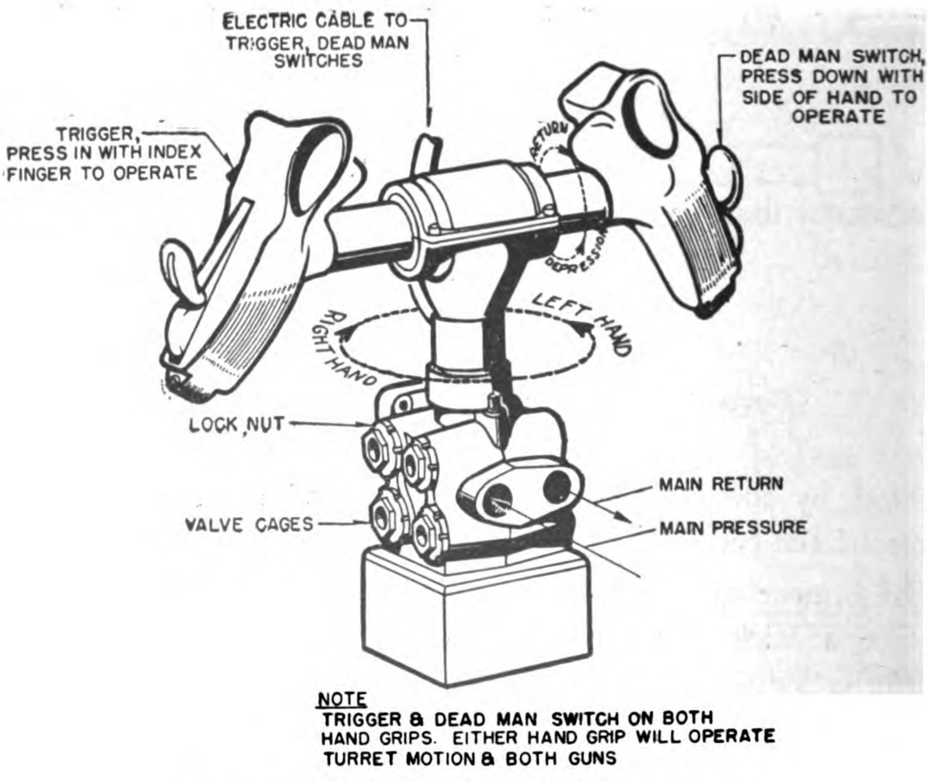

Figure 100.—The Clarke turret control valve.

surface are for the pressure and return lines. The four on the bottom are for the lines controlling both the horizontal and elevation movement of the turret and gun carriage.

You now have the hydraulic fluid being pumped through the system and its flow directed by the selector valves to and from a WORK UNIT, often an ACTUATING CYLINDER. But what is an actuating cylinder? What does it do?

Remember—hydraulics are never used alone to operate a mechanism. It is always necessary to use some form of mechanical device to start or finish the operation. The actuating cylinder is that device—the part of the hydraulic system that actually

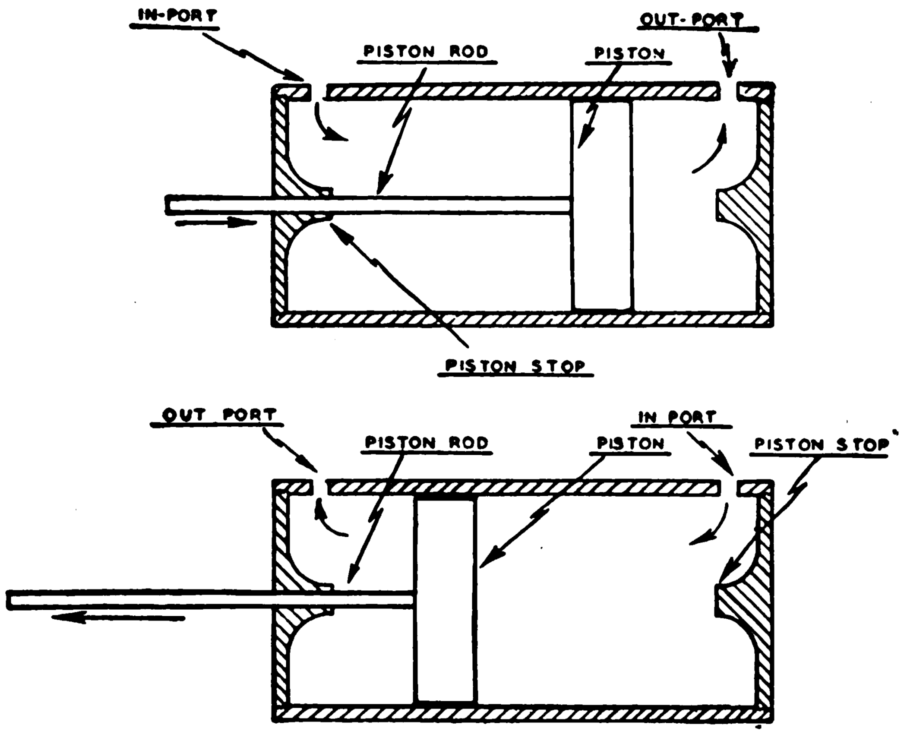

Figure 101.—Simple actuating cylinder.

imparts motion to, or actuates—the turret. Actuating cylinders are available in many shapes and sizes because their size and design must fit the job to be done. And these jobs vary a great deal.

The principles behind the operation of all such cylinders, however, are the same.

Figure 101 shows a simple actuating cylinder that operates in both directions by oil pressure. The cylinder is closed at both ends. Inside is a PISTON which operates a PISTON ROD on one end only. Seals or packings are installed on the piston and in the cylinder end around the piston rod to prevent the fluid from leaking.

PORTS opening into each end of the cylinder allow the hydraulic fluid to enter and leave. These ports alternate as inlet and outlet ports, depending on the flow to the cylinder from the selector valve.

In the top view, fluid under pressure enters the left-hand port and forces the piston toward the right-hand end of the cylinder. The motion of the piston is transmitted to a movable object by the PISTON ROD. As the piston moves forward in the cylinder, it pushes ahead of it (and out of the cylinder by way of the right-hand port) any fluid that is in the forward end of the cylinder. This fluid is carried back to the reservoir by the return lines.

Now, if you change the setting of the selector valve, the pressure line becomes the return line, and vice versa. Then fluid enters the forward end of the cylinder and the piston moves backward. As it does this, the piston shoves the fluid out of the back end of the cylinder.

By varying the DIAMETER of the PISTON, the force applied to the device to be operated can be varied. Therefore, actuating cylinders are made in various diameters depending on the force desired. The length of the cylinder depends on the required amount of movement of the part that is to be operated.

Double-acting cylinders are SELF-BLEEDING because fluid from the cylinder is returned to the reservoir during each stroke of the piston. Therefore, all air can be removed from the cylinder and connecting lines by several strokes of the piston.

Incidentally, a SINGLE-ACTING actuating cylinder is used on the HYDRAULIC GUN CHARGER, which you'll find on some turrets. This is a SPRING-RETURN type cylinder. It has a single fluid port at one end of the unit and a spring opposite. When fluid pressure is released, the spring forces the piston back into position.

HYDRAULIC MOTORS

In some cases, HYDRAULIC MOTORS are used in turrets instead of actuating cylinders. These motors MUST BE USED when it is desired to obtain rotary motion. Hydraulic motors are similar in construction to piston-type hydraulic pumps. The principal difference between the pumps and motors is in the arrangement of inlet and outlet valves.

A special type of control valve is used to control the direction and speed of hydraulic motors. This valve controls the VOLUME of fluid as well as the direction of flow.

A PISTON TYPE hydraulic MOTOR looks exactly like the Vickers piston pump, illustrated for you in figure 97.

It operates like this —

Fluid under pressure is introduced into either of the two ports in the pump body depending on the setting of the control valve. The other port (as with the actuating cylinder) becomes the return port.

If the fluid flows through the motor in one direction, the motor drive shaft turns one way. If the fluid flows through in

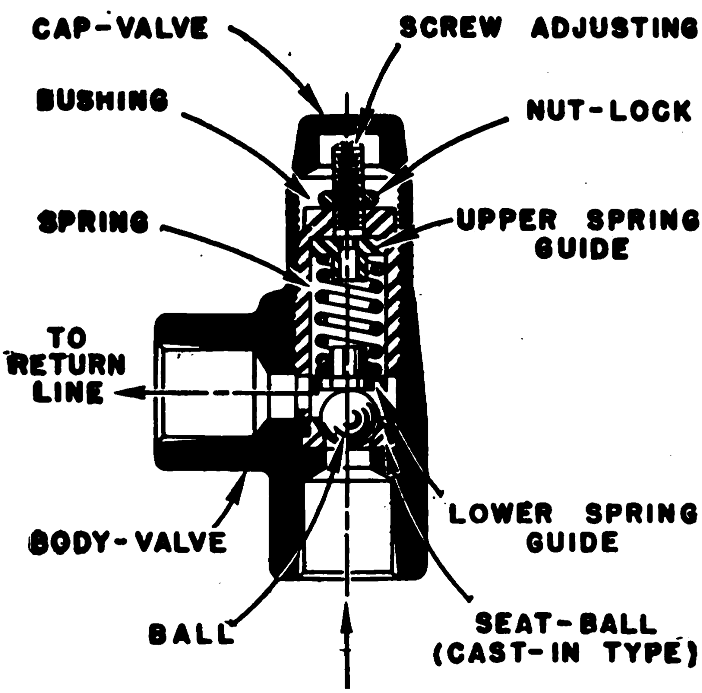

Figure 102.—A ball-type relief valve.

the other direction, the drive shaft turns the opposite way. The mechanical unit that is being operated turns in the same direction as the drive shaft.

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AUXILIARY HYDRAULIC UNITS

Now you've gotten the word on the more fundamental units making up a turret hydraulic system. There are other little gismos and gadgets, not so important fundamentally, perhaps, but helpful in a particular way to make the hydraulic operation smoother and more efficient.

Take RELIEF VALVES, for example.

They are placed in the hydraulic system to keep the pressure from too high a level and to control it if it threatens to get out of hand. In other words, relief valves are SAFETY VALVES.

Several types are used in the hydraulic systems.

In each case, the basic design involves a spring-loaded valve arranged so that it automatically opens to relieve the system pressure when the fluid pressure acting on one face of the valve becomes sufficient to overcome the spring pressure applied to the opposite face.

The relief valve closes immediately when the pressure drops to a value less than the spring loading.

Figure 102 shows a typical BALL-TYPE RELIEF VALVE. It employs a spring-loaded ball resting on a hardened steel valve seat inside a housing. An adjusting screw is installed so that the spring pressure can be varied and the operating limit of the relief valve regulated.

The valve is enclosed in a valve body containing integral inlet and outlet bosses and a valve seat.

A highly polished hardened-steel ball is held on the valve seat by a steel coil spring. This valve is held between two spring guides which are in the form of metal disks and have integral bosses which slip inside the spring ends. One of the spring guides bears on the ball while the other is in contact with the adjusting screw in the upper end of the relief valve.

The valve body is internally threaded at its upper end to receive a bushing that carries the adjusting screw and locknut. An aluminum alloy dust cap encloses the adjusting screw.

BALANCED RELIEF VALVE

The balanced-type relief valve, as illustrated in figure 103, has the advantage of smooth operation because it operates without the chattering effect produced by the ball-type valve. It operates in this manner —

Fluid from the pump enters port *A* and leaves through port *B* to enter the system. In the meantime, however, some of the fluid also goes through the metering hole *C* into the upper chamber and finds its way to the spring-loaded ball *D*. When the pressure reaches a predetermined value, it overcomes the spring *E* and unseats the ball *D*.

As the ball unseats, the fluid rushes past metering hole *C* and pressure is applied to the area of *H*. But, because the hole *C* is small, the hydraulic pressure reacts upward on *H*, moves

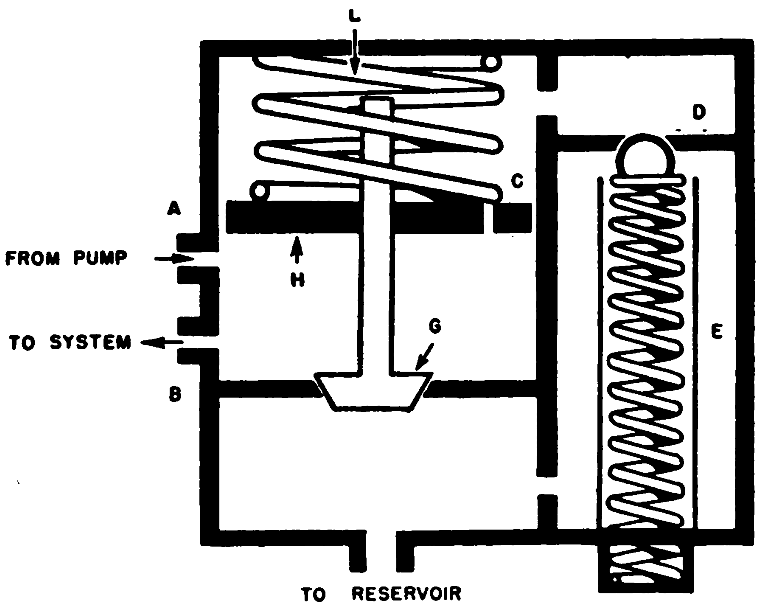


Figure 103.—Balanced-type relief valve.

it in the same direction, and at the same time unseats valve *G*. When this valve is unseated, the fluid from the pump is permitted to flow freely to the reservoir. When the spring *E* overcomes the oil pressure, ball *D* reseats and spring *L* assists *H* and *G* to return to their original positions. This permits the pressure to build up in the system again.

THE ACCUMULATOR—SYSTEM HANDY MAN

The ACCUMULATOR is just what you'd think it is. It ACCUMULATES potential hydraulic power.

The accumulator stores fluid when demands of the system are low. Then, when the capacity of the pump is insufficient to do all the work required of it, the accumulator feeds its reserve stock of fluid to the system units and keeps things going.

Not content with performing this valuable duty, the accumulator also serves as a SOURCE OF HYDRAULIC POWER when the pump fails to function and emergency operation of certain units is necessary. In its spare time, the accumulator acts as a surge

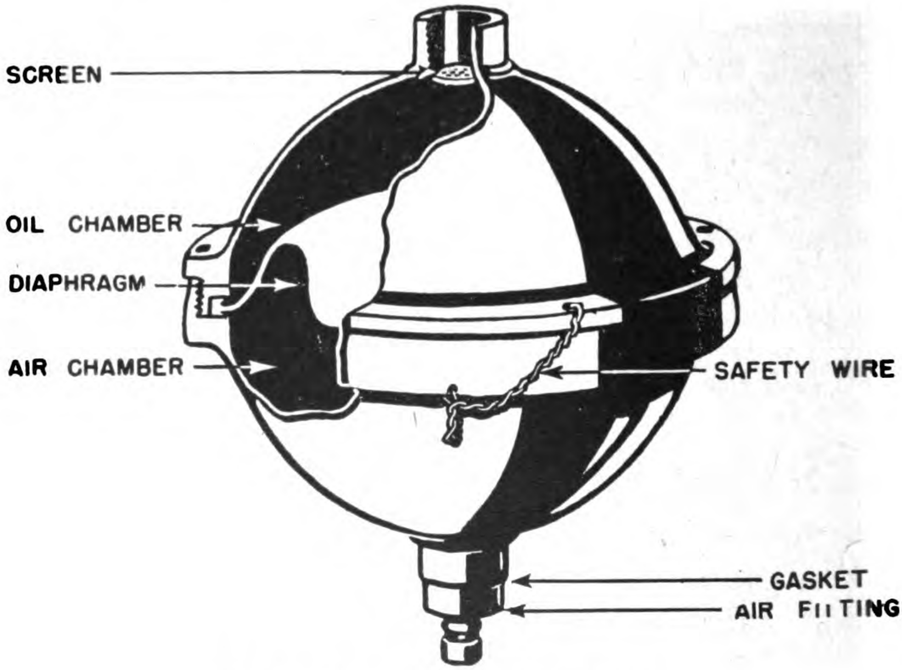


Figure 104.—Pressure accumulator.

chamber to prevent sudden surges of fluid pressure from damaging the system.

Actually, a pressure accumulator serves much the same purpose in the aircraft hydraulic system that the STORAGE BATTERY serves in the electrical system.

A spherical hydraulic-pressure accumulator, with a section of the outer shell removed, is shown in figure 104. This accumulator is made up of two forged steel hemispheres which are screwed together to form the complete sphere. The halves are separated by a rubber diaphragm thus forming two chambers. The upper chamber is the fluid chamber and is connected to the fluid supply line at a point close to the unit it is to operate. The lower half of the accumulator is the air pressure chamber and is fitted with an air valve (similar to the valve on automobile tires) for charging the chamber with compressed air. Air is pumped into the chamber at a pressure specified for each installation, usually one-third of the system operating pressure.

With the accumulator in the charged condition and the fluid chamber empty, the diaphragm is forced against the walls of the fluid chamber by air pressure. The introduction of fluid into the fluid chamber causes the diaphragm to be forced towards the walls of the air chamber. This further compresses the air charge and increases the pressure to that of the fluid.

When the fluid pressure in the line to which the fluid chamber is connected drops below the system's operating pressure,

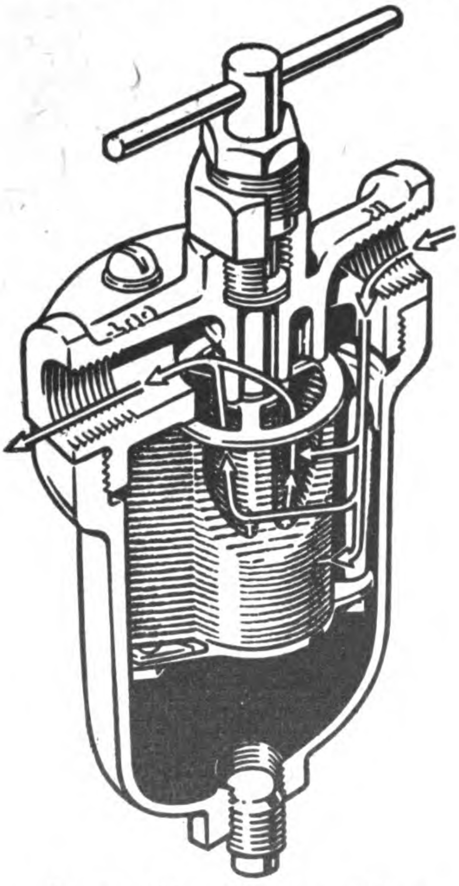


Figure 105.—Edge-type filter.

the air expands the forces the diaphragm toward the fluid chamber walls. This FORCES the fluid from the accumulator into the system.

The accumulator again becomes charged with fluid during periods when the demands of the system do not require the full output of the engine pump.

ROUNDING UP THE SABOTEURS

The filter (or strainer) stands guard at the reservoir to prevent any sabotage of the hydraulic fluid. Bits of metal, dirt, and other enemies are taken in hand and held in a concentration camp for ultimate disposal.

Figure 105 illustrates an EDGE-TYPE FILTER, the kind commonly used in hydraulic turrets. In this filter, the foreign matter is removed from the fluid when it passes between the surfaces of metal disks. It is then cleaned from the disks by rotating them with the handle. Cleaner blades which extend between each two adjacent rotating disks scrape the foreign matter from them and it drops to the bottom of the filter. These filters are also disassembled periodically and washed in a solvent.

Filters have integral bypass valves which open to allow fluid to pass if the filter element is clogged. This condition will not occur, however, if the filter handle is turned daily or before each flight and the filter element is cleaned regularly.

The filters are usually installed on the system return line, and that is the ideal location for them. Installation limitations, however, may make it necessary to install them on pressure lines.

CHECK VALVES

Check valves are the Shore Patrols of the turret hydraulic system. They are posted through the system, ever on the alert to keep the hydraulic fluid from entering spots that are out of bounds.

Spring-loaded ball-type check valves are encountered most frequently. The principle of operation is quite easy to understand.

The ball-type check valve is illustrated in figure 106. As you can see, the ball is held against its seat in the valve body by spring compression. Installed in a fluid line, the valve will remain in the closed position until the fluid pressure acting on the INLET side of the ball reaches a pressure greater than the combined spring and fluid pressure acting on the opposite side of the ball. Then — the ball leaves its seat and fluid is free to flow through the check valve in the direction indicated by arrows.

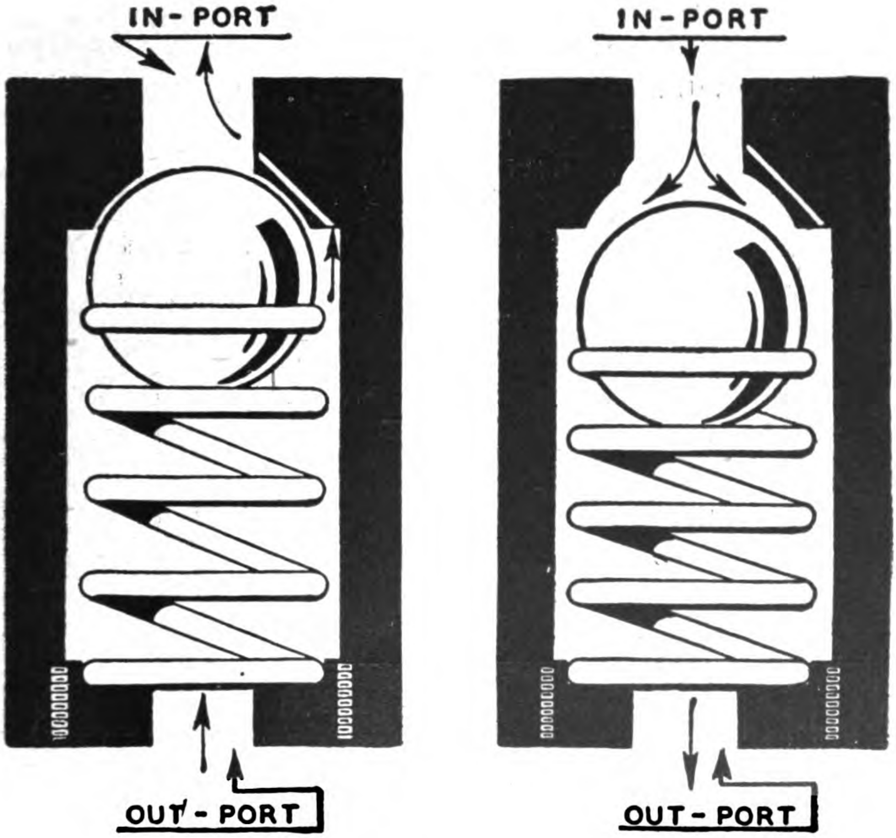


Figure 106.—Ball-check valve.

As soon as the fluid pressure in the INLET side of the ball drops below that on the OUTLET side, the spring returns the ball to its seat and prevents fluid from flowing in the opposite direction. In this way, fluid pressure is maintained in the portion of the system that is protected by the check valve.

In hydraulic lines where it is particularly important to prevent the reverse flow of any fluid, a DOUBLE ball-check valve is used. This valve has the same effect as installing two separate check valves in the line. There is not much chance of both valves in the double ball-check valve being held open by foreign particles at the same time. Thus the safety factor is doubled.

EVERYTHING AT ONCE

Now you can get down to business and tie the individual units of the turret hydraulic system together. Figure 107 is a schematic of a real turret system — that of the Erco 250 TH–1. Rather simple, isn't it?

Note that this particular turret uses hydraulic CYLINDERS as power actuating units, both in elevation and azimuth. Some

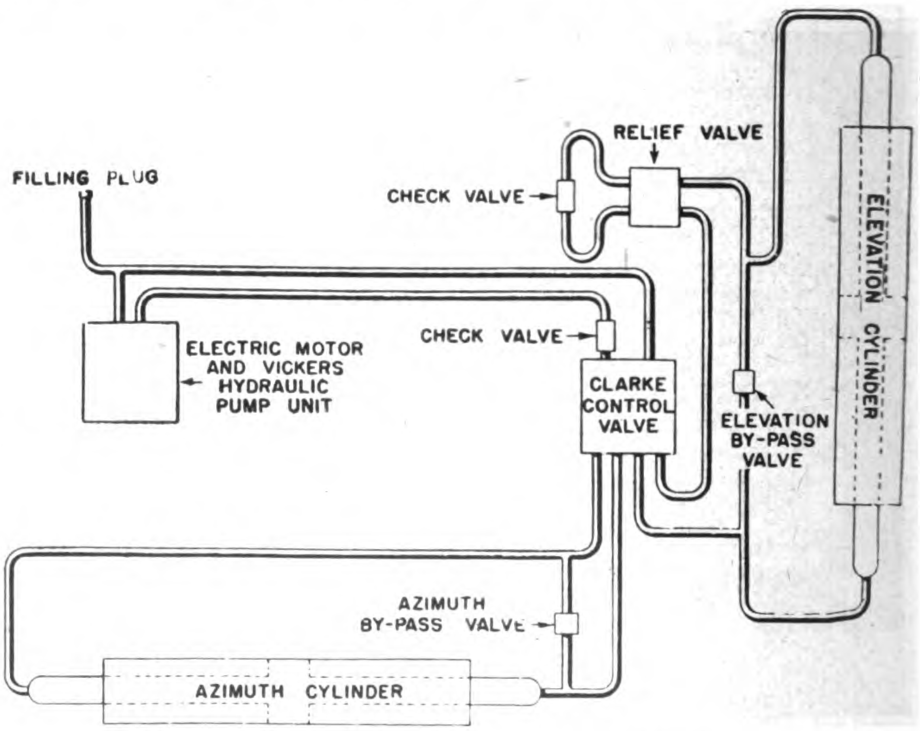


Figure 107.—Schematic of hydraulic system.

hydraulic turrets use hydraulic MOTORS as work units, particularly for rotary motion. Otherwise, the units of the Erco are common to all hydraulic turrets.

It's too bad, but to be quite frank, there isn't much uniformity in hydraulic symbols. Some manufacturers use one set and another manufacturer will make up a different set that suits him better. However, the symbols shown in figure 108 are used as much as any, and a little study of them will help you understand most hydraulic diagrams.

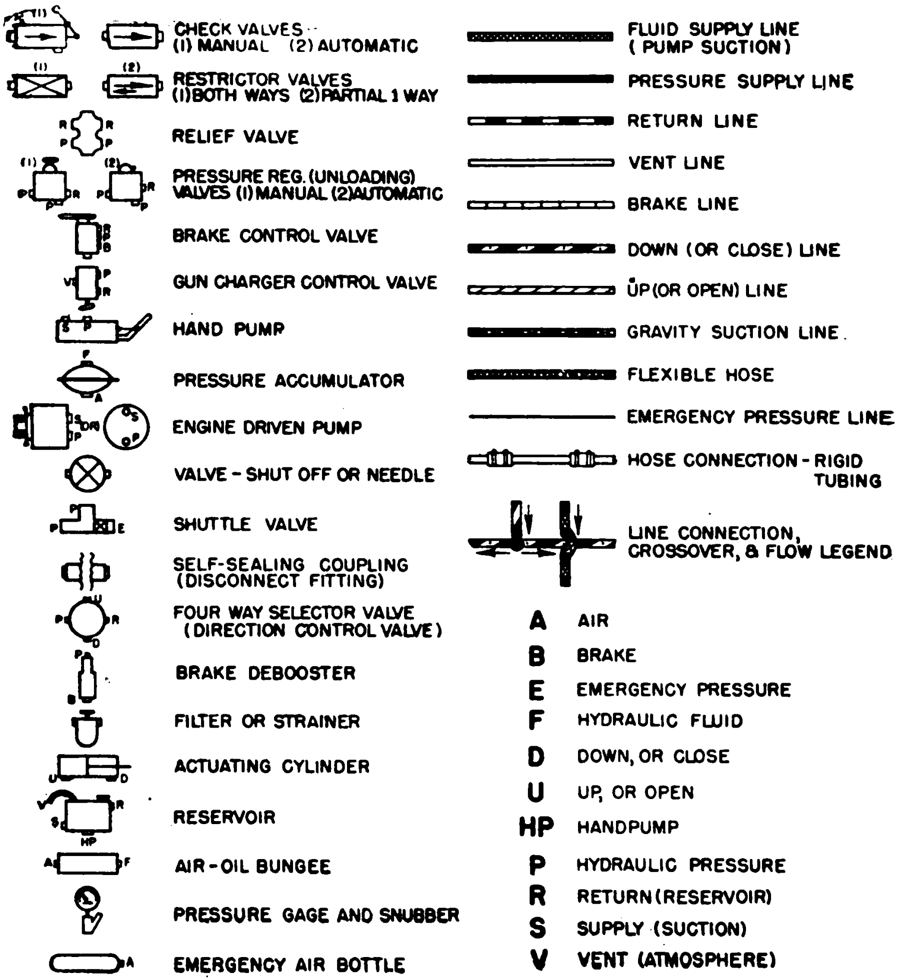
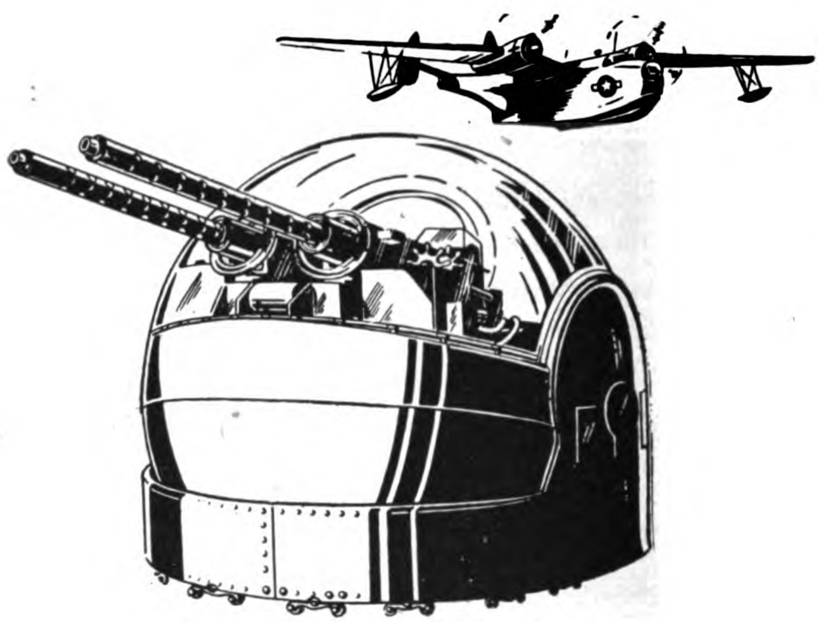


Figure 108.—Hydraulic symbols.



CHAPTER 6

MARTIN 250 SH–2 TURRET

HYDRAULICS AT WORK

Now that you are acquainted with the primary units of the turret hydraulic system and the auxiliary units which improve the efficiency of the basic system, you're about ready to put them together. When you do, you'll have a complete turret hydraulic system.

The MARTIN 250 SH–2 TURRET will give you a pretty comprehensive idea of how these units fit together and relate to one another. In fact, if you understand how this turret works, you won't have much trouble with any other hydraulic turret.

The 250 SH–2 is mounted in the bow position of the PB2Y. Very similar Martin turrets are used in the PBM. The Martin 250 SH–3 is the same as the 250 SH–2, except that the PARKER ELEVATION UNIT, which you'll learn about in this chapter, is replaced by the Vickers motor.

As the designation tells you, the Martin 250 SH–2 carries two .50 caliber machine guns. They protrude from the upper half of the turret. The turret carries 800 rounds of ammunition to feed into these guns. A one-piece, transparent plexiglas enclosure makes up the top half of the turret. It houses the gunner, the guns, accessories, armor plate, and all the operating mechanisms except the horizontal driving unit.

The MARTIN 250 SH–2 turret is composed of two main parts, known as the BALL and the SADDLE. As you can see in figure 109, the ball is a sphere slightly flattened on two opposite sides. These flat surfaces fit inside the hubs of the saddle, which is a cylindrical shell with the two hubs projecting above it. In

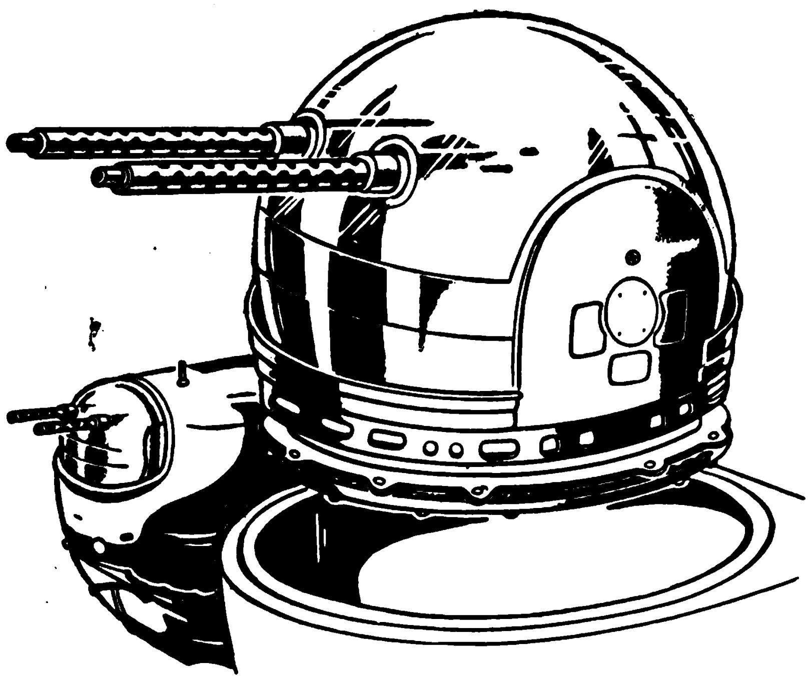


Figure 109.—Ball and saddle (assembled).

vertical rotation, the ball moves about the axis formed between two horizontal trunnion tubes which support it. Horizontal movement is accomplished by the rotation of the saddle on a track. Rollers on the saddle ride on this track, which is bolted to the airplane structure.

HOW TO OPERATE IT

This Martin turret will rotate in azimuth to 79 degrees on either side of the center line of the airplane. You can move the guns 87 degrees above the horizontal or depress them 33 degrees below horizontal.

Now assume that the turret is all set to operate. This means that the hydraulic system is completely filled with fluid (it holds six quarts) and all units are intact and in good working order.

Be sure the turret is locked before you start to get in. Otherwise, it can swing down and pin you part way in and part way out.

Facing forward, you enter the turret through an opening in the bottom and reach up, grasping the top of the front armor plate to pull yourself aboard. Once inside, reach down on your left side and release the seat lock, allowing the seat to follow the track to its seated position.

At this point, you can take a look through the Mark 9 illuminated sight to see if you're at the right height. If not, you can adjust the height with the seat adjustment handle, which you can reach with your right hand underneath the seat.

Take a look at your pressure gauge, which you'll find down by your right ankle. It should read 25-30 pounds before the turret is ready to operate.

Now unlock the elevation landing lock, which is on the forward left-hand side of the ball, by pulling out the handle and moving it up. Then determine if the azimuth position lock on the lower left-hand side is in the extreme unlocked position. These two operations free the turret so it can rotate.

You can turn on the juice at this point. The main power switch is on the control panel, which is located on the upper right-hand side of the turret. When the switch goes on, a red indicator light shows up, both on the panel and outside of the junction box.

Then you can turn on the pump motor. The control switch is marked on the bottom of the control box. The pressure gauge should indicate that the pump has built up from 960 to 1,000 psi.

The turret actually rotates when you move the control handles. You can't miss these, since they are directly in front of the gunner's position in the turret. Moving them to right or left will move the turret correspondingly in azimuth. Moving them up or down will elevate or depress the guns. If you combine both motions, you can move the turret in a diagonal direction. The degree of rotation determines the speed.

Right under your index finger on both control handles are the triggers which control the firing of the guns. Either trigger can fire both guns. Next to your left knee is the hydraulic gun charger control mount, which operates the gun charger located on the outboard side of each gun. If you want to charge the guns, turn the control knob to the "Fire" position. If the control knob is turned to the "Safe" position, the gun bolts will remain retracted, and of course, the guns will not fire.

Now that you've gotten in the turret and found out how it operates, you'll have to know how to get out of the turret. First of all, you'll move the turret to stowing position — that means the guns are centered both in azimuth and elevation. Now turn off all the switches. With the hand pump, you can rock the turret slightly until you can slip the elevation landing lock pin into position. Then reach down on the lower left-hand side of the ball and turn the azimuth position lock to "ON."

IT IS MOST IMPORTANT THAT THESE LOCKS BE SECURED. Otherwise, the turret can swing around freely and can damage

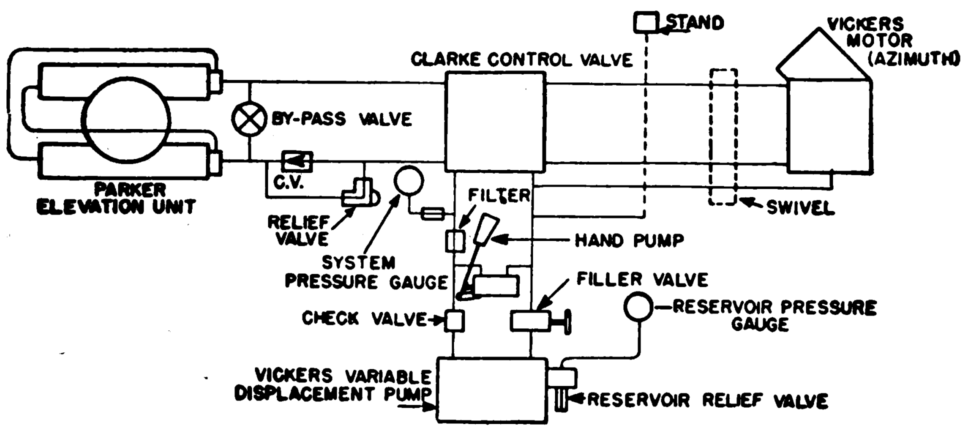


Figure 110.—Flow diagram of Martin 250 SH–2 hydraulic system.

the aircraft. Now brace yourself against the back of the turret seat rest, lift up the seat, and move it out of the way on the seat track.

Then grasp the top of the front armor plate to let yourself down.

You've learned HOW the Martin 250 SH–2 operates. Now you can investigate WHY it operates.

Figure 110 is a flow diagram which shows you the various units which make up the Martin 250 SH–2 hydraulic system.

As the diagram shows, the hydraulic power in this turret is provided by a VICKERS VARIABLE DISPLACEMENT PUMP — the same kind you learned about in the previous chapter. This pump contains a reservoir, pump, compensating valve (this acts as a regulator), emergency relief valve, and a supercharger to pressurize the reservoir. The pressure output of this pump can be regulated by turning a set screw on a compensating valve. This is the only external adjustment on the pump unit, and there are no internal adjustments.

The variable volume pump is splined to a right angle gear box which is built integrally with the electric motor. An electric

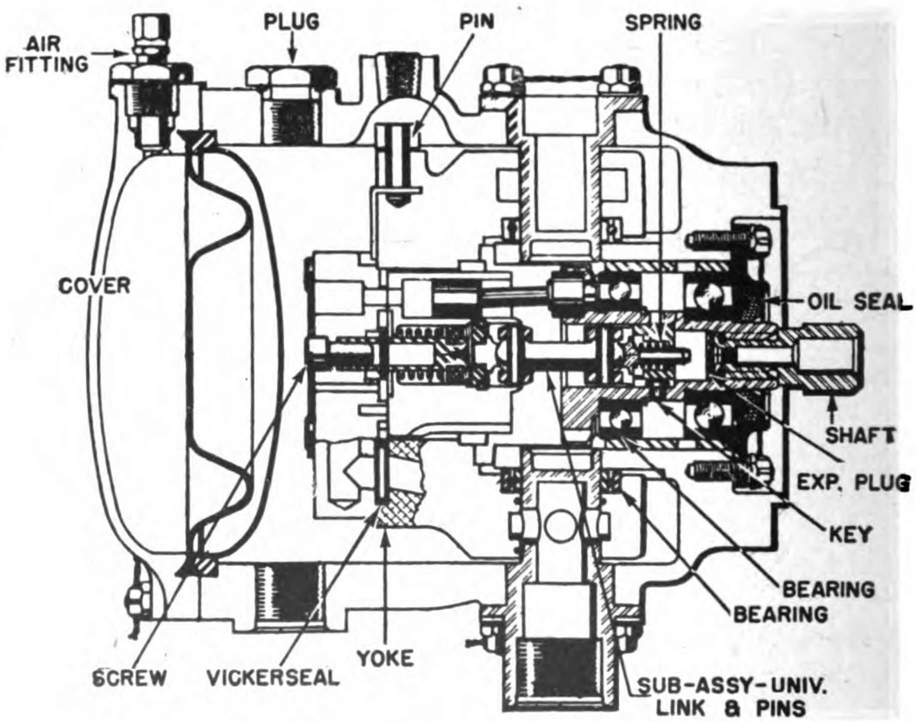


Figure 111.—Cross-section of Vickers variable pump.

conduit runs from the electric motor up to a junction box. Two large hydraulic tubes, one pressure and the other return, attach to the aft face of the pump. On the forward face there is an air connection for pumping up the supercharge pressure and a tube connection where a relief valve attaches. From this relief valve, a tube goes to the low pressure gage.

As you already know, this Vickers pump supplies oil at a variable rate of flow, within a predetermined pressure range. The flow rate is controlled automatically.

When the pressure goes down, it increases. When the pressure goes up, it decreases.

It would be too good to be true if you never ran into trouble with hydraulic systems. When the pump isn't working right, the whole hydraulic system, and the turret itself, won't operate properly, if at all.

That's the time your skill and knowledge come to the front. If the pump isn't working right, your first step is to diagnose the trouble, then apply the cure. Remember, YOU'RE THE DOCTOR! But you're not a SPECIALIST in pumps. So unless you can repair the trouble quickly and easily, better REPLACE the pump and send the old one to the nearest overhaul point.

The descriptions which follow indicate some of the MOST COMMON pump troubles, what causes them, and how you can cure them.

TROUBLE: Pump not developing pressure

CAUSE	CURE
Broken parts, or	Replace pump or part. Send old one to overhaul point.
Valving surfaces scored by abrasive in oil, or	Relap or replace scored parts or return to overhaul point for repair and complete performance test.
Leaks in hydraulic control system (cylinders or valves).	Restrict pressure line close to pump, and check pressure between restriction and pump.

TROUBLE: Pump overheating

CAUSE	CURE
Pressure control sticking, allowing pump to operate at full volume against maximum pressure.	Remove back cover and check linkage of pressure control. Dismantle pressure control if necessary, and check internal parts.

TROUBLE: Air in hydraulic system

CAUSE	CURE
Pump taking in air through case or shaft oil seal, or	Check oil level and fill housing full. Check air pressure in supercharging chamber.
System not properly bled, or	Install air vents at highest points in system and bleed air from lines.
System taking in air due to high velocity of oil through an obstruction.	Straighten out piping, eliminate undersize lines and obstructions wherever possible. Refer to nomographic chart if available.

TROUBLE: Pump not delivering oil

CAUSE	CURE
Oil viscosity too high, or	Use mineral oil meeting Navy specifications for aircraft hydraulic system.
Blown Vickers Seals 49617, or	Remove valve plate 54945 and check these seals; blown seals allow oil to short circuit.
Blown seals 46476, or	Remove pintle and check these seals.
Wrong direction of shaft rotation, or	Must be reversed immediately to prevent seizure and breakage of internal parts due to lack of oil.
Oil level low in housing, or	Add recommended oil, and check level to be certain housing is full.
Inlet port of valve plate clogged, or	Check to make certain no foreign matter has covered inlet port.
Broken pump shaft or internal parts, or	Remove pump and replace coupling shaft.
Yoke on center.	Remove back cover 62852 as in manufacturer's instruction sheet and check position of yoke. It should not be on center. If yoke is on center, check linkage to be sure it is connected, or remove pressure regulator and check per instruction sheet. Spring might be broken.

TROUBLE: External leakage around pump

CAUSE	CURE
Diaphragm 62850 ruptured or not sealing properly, or	Remove back cover 62852 and replace diaphragm if ruptured, or if not ruptured, smear rim with clean oil and replace.
Shaft oil seal worn, or	Replace shaft oil seal 51756 by removing retainer 62355, or return to overhaul.
Gasket blown, or	Replace gasket.
Loose plug.	Tighten plug.

In case you want to REMOVE the variable volume pump, start by disconnecting all tubing. Remove the bolts holding the pump to the pump brackets and lift the pump out.

The variable volume pump and pump motor can both be taken out at the same time if you will disconnect the electrical conduit from the junction box to the pump motor. After removing both as a unit, you can take them apart by removing the attaching bolts.

The system RELIEF VALVE, which you will remember is located in the pump, may need adjusting. If it does, it should be sent to a regular pump overhaul shop. So your best bet is to install a new pump and ship the old one, including the relief valve, to overhaul.

NOW FOR THE CONTROL VALVE

The CLARKE CONTROL VALVE, another of the basic units you learned about in the previous chapter, is an important feature

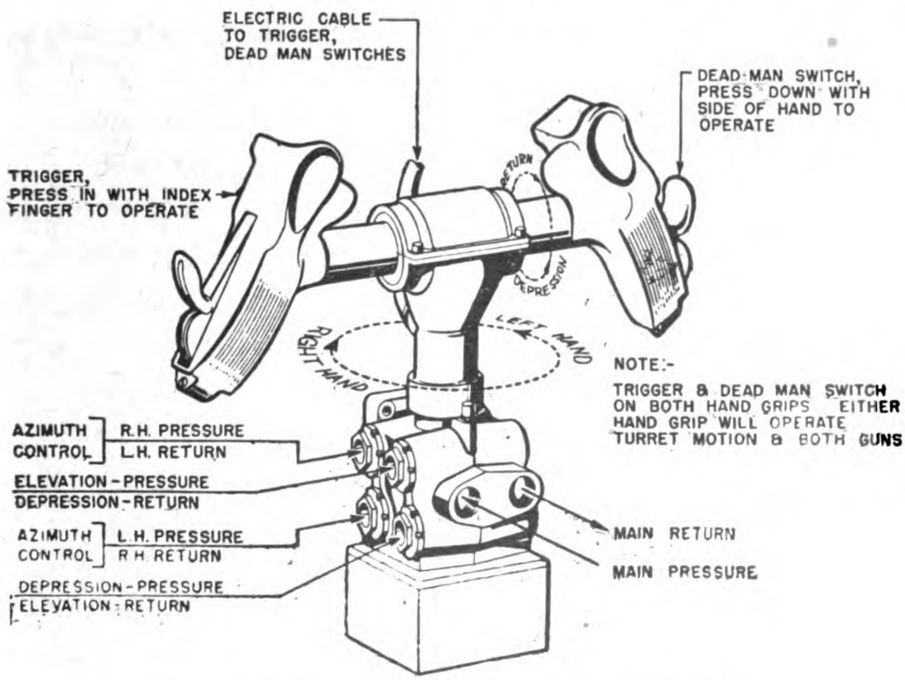


Figure 112.—The Clarke turret control valve.

of the Martin 250 SH–2, as it is on most turrets. This valve is located on the vertical center line of the turret, between the gunner's knees.

Figure 112 shows you the Clarke control valve again, complete with the control handles, switches, and triggers. Two hydraulic ports, the pressure and the return, face aft. Four ports face to the left. Two of these are connections for the azimuth drive, and two for the elevation drive.

The power units generally consist of hydraulic motors or cylinders suitably geared or connected to the turret mechanism. It is necessary to control the amount of hydraulic fluid acting upon the hydraulic motors or cylinders so that either will operate smoothly through all speed ranges from zero to the maximum required in either train, elevation, or a combination of both. The capacity of the pump is limited, however, so the turret will not operate at maximum speed in both directions at the same time.

The turret valve is so designed that it is convenient to use the four-way valves singly or both together. In order to control the amount of fluid passing through each four-way valve, a single vertical control column is used. The entire vertical control column assembly turns about a vertical axis on bearings contained in the housing.

After you have bolted the control valve to the supporting member in the turret, connect the high pressure line to the port marked "PRES." Connect the return line to the port marked "RET." To the port marked "U," connect the line that controls the UP movement of the turret. To the port marked "D," connect the line that controls the DOWN movement of the turret. Connect the line that will turn the turret to the right to the port marked "R." To the port marked "L," connect the line that will turn the turret to the left. DO NOT DAMAGE VALVES BY CONNECTING WRONG LINES TO THE WRONG PORTS. If the lines are reversed, you will find yourself turning in the opposite direction to which you want to go.

To adjust the Clarke control valve, loosen the locknuts. Screw both cages in until they strike the bottom. Back each of the valve cages out the same amount, approximately one and one-half to two turns, until the neutral position is definite and noticeable in both movements of the control handle.

The two valve cages, which control the turning of the turret left and right, are at your left as you face the sketch in figure 112. The elevation and depression valve cages are at the right.

Adjust one pair of the cages at a time by turning each valve inward an equal amount until the desired neutral play or "feel" is obtained. Now tighten the locknuts you loosened when you started to adjust the valve. When you tighten the locknuts the valve cages will be pulled slightly, so be sure and allow for this condition when adjusting.

If the control valve is giving trouble, check its performance with the descriptions which follow. But once again, DON'T TRY TO DO TOO MUCH. If it looks as if a major overhaul is required, call on the nearest overhaul point. That's what they're for.

Here are some common Clarke valve troubles and what to do about them —

TROUBLE: Stiffness and excessive handle load in train control

CAUSE	CURE
Mechanical friction occurring in the bearings.	Remove cover D1307B. Loosen the pivot arms and actuating link sub-assembly D1405A, by removing the screw that clamps it to the torque tube. Readjust the locknut, and clamp sub-assembly back in place.

TROUBLE: Leakage from around guide screw D1164A

CAUSE	CURE
Guide screw loose, or Imperfect crush washer CS1289A.	Tighten screw. Remove guide screw and replace crush washer. Care should be taken when replacing screw to see that the guide prong on the end of the screw properly engages the hole in the sleeve and the slot in the valve.

TROUBLE: Excessive neutral play in elevation control

CAUSE	CURE
Improper adjustments of elevation cages.	Loosen locknuts D1156A on the elevating cages and back each cage out the same amount until a very definite neutral position is noticeable. Turn each cage IN the same amount until a very definite neutral position tained. (The valve should be under full operating pressure when making this adjustment.)

TROUBLE: Excessive neutral play in train control

CAUSE	CURE
Improper adjustments of train cages.	Same as above operation with train cages.

TROUBLE: Mushy or spongy feeling in neutral position of valve

CAUSE	CURE
Foreign particles lodged between the valve plungers and the liners.	Remove cages, and check for dirt. Remove dirt, and flush with clean fluid.

TROUBLE: Stiffness or excessive handle load in the elevation control

CAUSE	CURE
Mechanical friction occurring somewhere in the linkage between hand grips and the cam shaft.	Move hand grips through the elevation cycles with the pressure OFF. If a noticeable amount of resistance is found, loosen the locknuts that hold the shaft in axial alinement. If the trouble is not in the adjustment of the handle shaft bearings, follow the linkage motion down through the column to the bottom of the valve, making sure that no dirt has worked into any of the moving parts.

WHAT MAKES IT ELEVATE?

A Parker hydraulic elevating unit is mounted on the left-hand side of the Martin 250 SH-2 turret on the horizontal and vertical centerline. It consists of a large housing which contains a central spur gear fastened to the left turret trunnion tube, which in turn is attached to the saddle. Above and below this gear are two racks lying in a horizontal plane and meshing with the gear.

On each side of the racks are pistons. These pistons are driven by HYDRAULIC PRESSURE, regulated by the CONTROL VALVE. This makes each rack DOUBLE-ACTING. Opposite ends of the two racks are interconnected. This provides rotation of the ball structure to aim the guns in elevation.

The elevating unit should not be removed except to replace a damaged unit, and the removal should be done only in a machine shop capable of such work.

The hydraulic swivel joint fits inside the left-hand trunnion and elevating unit. It carries the flow of three separate hydraulic lines from the ball to the saddlle. Two of these lines run from the control valve to the azimuth motor, and the third is a drain line from the azimuth motor back to the low pressure side of the pump.

EXAMINE THE AZIMUTH DRIVE

The azimuth drive unit is bolted to the roller casting under the left-hand hub on the saddle. It consists of three parts —

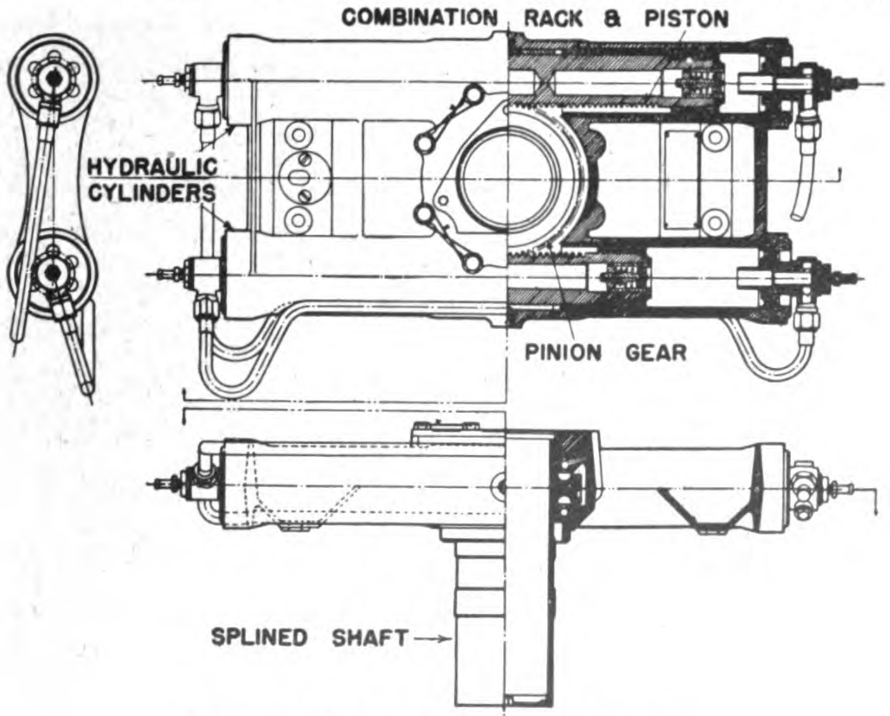


Figure 113.—The Parker elevating unit.

a main gear box, a hydraulic motor, and a 90-degree manual drive gear box.

The main gear box comprises a worm and gear enclosed in a housing with a small pinion outside on a shaft, which meshes with the large ring gear on the turret track. At right angles to this latter shaft is the worm shaft with a spline on each end. A seven-cylinder fixed-stroke motor connects on one end of the worm shaft.

On the other end of the worm shaft, the 90-degree manual drive attaches. There is a square shaft projecting from this,

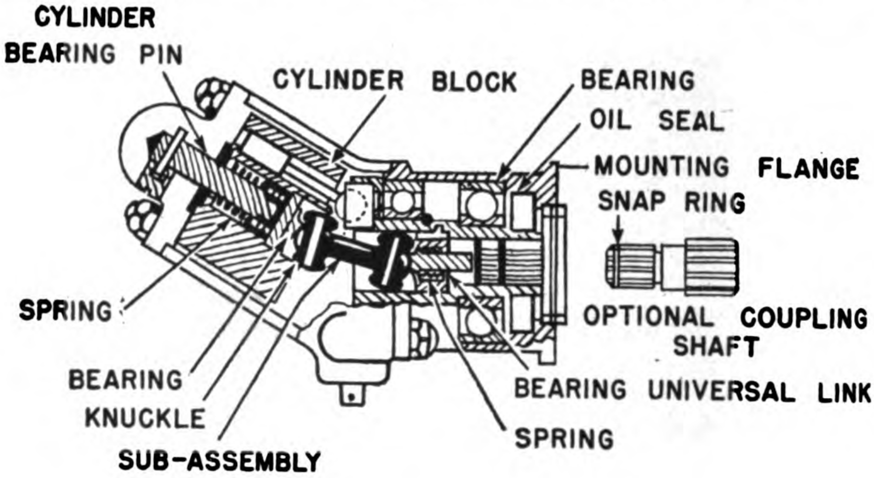


Figure 114.—Cross-section of azimuth motor.

to which may be attached a hand crank for manual movement (from outside the turret) of the turret in azimuth.

Here are a few common complaints that can develop in an azimuth motor —

TROUBLE: Motor not turning over or not developing sufficient speed or power

CAUSE	CURE
System overload relief valve not set at correct pressure, or	Check system pressure and reset relief valve.
Driving mechanism binding because of misalinement or other damage, or	Install new motor, unless you can easily realine.
Scored valving surface on connecting cover (X) or scored cylinder block (#46260) due to foreign matter in oil system.	Replace damaged parts.

TROUBLE: Motor not turning over or not developing sufficient speed or power

CAUSE	CURE
Pumps or other components in system not functioning as intended, or	Check system thoroughly—particularly pump pressure and delivery.
Incorrect motor model for particular circuit.	Check model number, replace with correct size motor.

TROUBLE: Motor turning in wrong direction

CAUSE	CURE
Tubing between control valve and motor are mixed up.	Correct tubing connections, being sure that the right tube goes to each valve opening.

TROUBLE: External oil leakage from motor

CAUSE	CURE
Oil seal 48637 worn, or plug 41814 damaged, or	Check shaft drive coupling alinement, and replace oil seal or expansion plug.
Gaskets leaking because reservoir drain is improperly connected.	Drain line must be piped directly to oil reservoir.

TROUBLE: Motor idling or drifting when control is in OFF position

CAUSE	CURE
Control valve not closing in the OFF position.	Check control valve for port leakage.

The HYDRAULIC HAND PUMP is provided in case of failure of electric power, and probably more important, for providing a handy source of hydraulic power for test purposes. It is a double-acting wobble pump connected between the main pressure and return lines of the hydraulic system. The term "double-acting" is used because the pump discharges fluid during both strokes of the handle — up and down. There is nothing much to worry about in the way of service or maintenance. Its construction and operation are the same as in the hand pump you saw in figure 96.

SOMETHING EXTRA

The Martin 250 SH–2 turret has an accumulator connected to the hydraulic system as an AUXILIARY RESERVOIR. It supplies fluid to refill the hydraulic system when the gun chargers are operated.

It is similar in construction to the accumulator described earlier. A rubber diaphragm separates the two halves of a steel ball into a fluid chamber and an air chamber.

If you want to remove the accumulator from the turret, first relieve the air pressure, disconnect all hydraulic lines, and remove the bolts holding the top clamps in position.

Now that you have removed the accumulator, all that is necessary to dismantle it is to unscrew the halves with two special wrenches designed for the purpose.

Be very careful you do not damage the ring lip on the diaphragm, and do not tighten excessively when putting the accumulator back together.

Accumulators are easy to maintain, since their construction and operation is relatively simple. A few difficulties, and remedies for them, are described below.

TROUBLE: Leakage of oil or air at joint between oil and air chambers

CAUSE	CURE
Chambers not tightly screwed together, or Damaged sealing ring lip on diaphragm.	Tighten (R.H. thread) with two special wrenches #51661 supplied by Vickers, Inc. Dismantle to check. Replace diaphragm if necessary.

TROUBLE: Loss of air in air chamber

CAUSE	CURE
Punctured or torn diaphragm or air leakage as above, or at air fitting (Vickers part #47136).	Replace valve core of air fitting, gasket (Vickers part #61182), or both. If cause not at air fitting, dismantle and check diaphragm for leaks. Replace if necessary.

TROUBLE: Loss of system pressure

CAUSE	CURE
Leakage of other units in system.	Check all units directly connected to accumulator system for leakage. If all are OK, check accumulator for these conditions.

Any one of these conditions can exist in the accumulator WITHOUT causing complete failure of the entire hydraulic system, provided the pump is operating and provided there is oil in the system. Should there be failure of operation of any components dependent upon accumulator oil reserve (when pump is not running), check for loss of system pressure FIRST, then for the other possible troubles, described in the preceding list.

MEET THE CHARGERS

The two machine guns mounted in the Martin 250 SH–2 turret are provided with HYDRAULIC GUN CHARGERS, which are mounted to the outboard side of either gun. Pressure for their

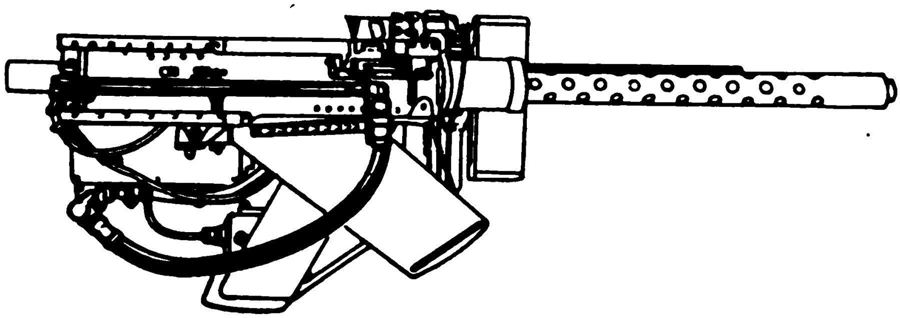


Figure 115.—Hydraulic gun charger (cross-section).

operation is obtained from the turret hydraulic system and the accumulator.

It is the operation of these gun chargers that makes the accumulator necessary, since it maintains reserve pressure to replace that diverted by the chargers.

The charger VALVE operates the gun chargers. The charger valve handle is pushed down to operate the chargers, and by rotating the handle, the charger is held in either a safe position or in the firing position.

Here's how to operate the gun charger —

Set the control handles in the firing position. Depress the plunger through a stroke of 3/8 inch. The valve plunger will remain in this open position. When the valve plunger is in open position, fluid is free to flow to the charger cylinder until the gun bolt is full retracted. When the gun bolt strikes the gun buffers, the valve plunger will automatically close, opening the passage from the charging cylinder to the return line and allowing the hydraulic charger cylinder piston to return as the fluid is discharged from the cylinder by action of the charger spring.

A SAFETY FEATURE is incorporated in the charging system whereby it is impossible to fire the gun, should the firing switch be inadvertently closed. To hold the gun safe, the control valve handle is turned counterclockwise, and then depressed. The valve will AUTOMATICALLY close in the manner previously described, but the hydraulic fluid will remain trapped in the line. In this way the gun will be safe until the handle is rotated clockwise to the firing position, in which case the fluid is exhausted from the cylinder and the bolt returns forward for firing. REMEMBER, this operation is safe only when the motor is running.

If, for any reason, you have taken down and reassembled the charger control valve, the spring will require adjustment. This can be done with either a hand pump or a power operated pump with an adjustable relief valve.

The valve should be put in the open position and the pressure gradually increased until the valve plunger kicks out.

The spring should be adjusted by the adjusting screw, in or out as required, until the necessary kick-out pressure is reached.

FILLING AND BLEEDING

You can save yourself a lot of time and possible worry if you will always remember that improper filling and bleeding is THE CAUSE OF MANY TURRET ILLS. Air in the hydraulic system is just as fatal to the proper operation of the system as air would be if it got into your own blood system.

The term "bleeding" the hydraulic system is nothing more than FORCING ALL AIR OUT of the system.

Filling, naturally enough, is filling the system with the hydraulic fluid. As long as this fluid is clean, and as long as the turret hydraulic system is filled to capacity, with NO AIR in the system, you will find that hydraulic turret difficulties are very few and far between.

Filling and bleeding is accomplished through the use of a FILLER CAN and in the case of turrets so equipped, with the use of the FILLER VALVE. The best kind of filler can is illustrated in figure 116. The two flexible hoses are about three feet in length, and they are equipped at the ends with shut-off valves. You can easily make a filler can out of an empty oil can, if you need to.

The operation you are about to undertake is a one-man job, due to the limited working space inside the turret. However, you will have to have an assistant to hold the can for you, or if this is not possible, you will need to attach the can to something HIGHER than the turret to be filled. It must remain higher AT ALL TIMES. The can should be filled with hydraulic oil, Specification AN-VV-O-336b.

Get inside the turret through the escape hatch, and take the flexible hose in with you, or get your assistant to pass it in to

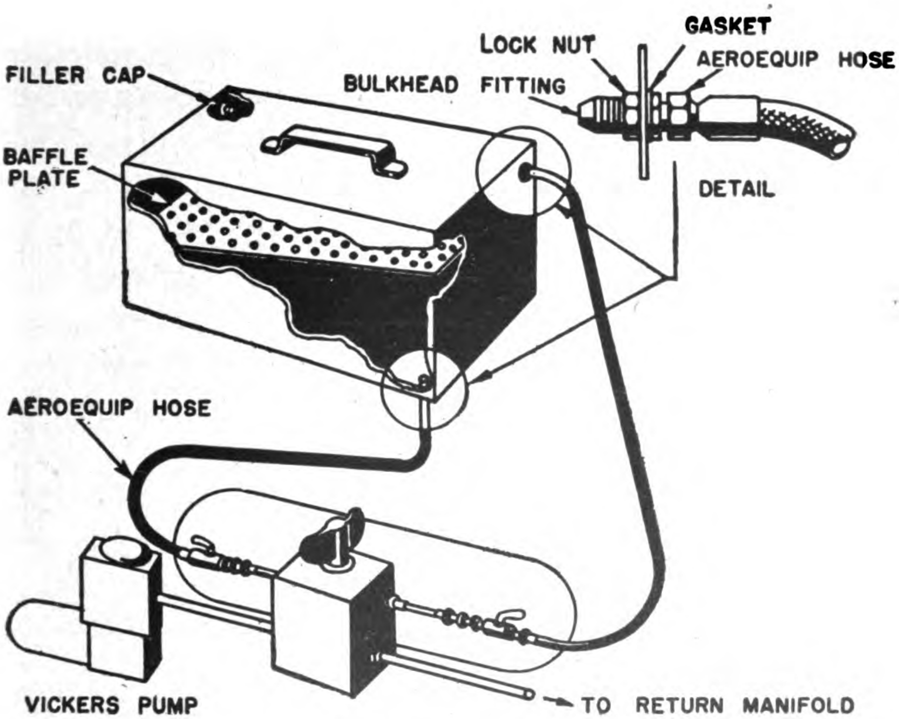


Figure 116.—Filler can.

you. There is a Schrader valve located on the Vickers accumulator. If you remove the valve core, you will reduce the preload to zero within the accumulator and you are ready to start your bleeding and filling operation.

Connect the tube at the bottom of the filler can to the INLET port (½ inch tube size) of the FILLER VALVE. Then connect the tube at the top of the filler can to the RETURN port (3/8 inch tube size) of the filler valve.

Now turn the lever at the top of the filler valve to the FILL position. Open both shut-off valves at the end of the hose connecting with the filler valve.

Now apply a pressure of 10 to 15 psi to the supercharging chamber of the Vickers pump. This pressure can be applied with an air line or with a hand pump. Check it with a reliable tire gauge.

The next step is to operate the turret slowly to all extreme positions until air is removed from the system. You can tell when this occurs by watching for bubbles in the filler can. When there are no more bubbles, there is no more air in the system. Don't forget to operate the turret slowly and to run it to the extreme limits both in azimuth and elevation. About one-fourth maximum speed should be tops in this operation.

The reason why it is so important to operate the turret slowly is that when a filling can is being used, the pump feed pressure is low. Therefore, if the pump is operated at too high a speed, it is likely to feed and draw air into the system, which is just exactly what you don't want to have happen.

Usually, you should get all the air out of the system in not more than ten minutes.

Now loosen the filler cap and nut on the line to the pump, and bleed both of your lines.

Operate the turret slowly for three minutes after the operation becomes smooth and free from jerkiness, and then turn the pump off.

Release the air from the pump supercharging chamber by removing the core of the pneumatic valve located on this chamber's cover plate. Now turn the turret power on again and run the turret for a couple of minutes more. This replaces the volume of air just released from the supercharging chamber of the pump with hydraulic fluid.

Now turn the turret power off again and switch the index lever of the filler valve to the RUN position. Replace the Schrader valve core in the supercharging chamber of the pump. Put the dust cap back on the valve and tighten it up with a wrench. It is VERY IMPORTANT that no dirt or dust get into the system.

Close both the shut-off valves which you opened previously at the end of the hose connecting to the filler valve. Disconnect this hose from the filler valve. Cap the two ports of the filler valve simultaneously with the removal of the hose.

You will have to be QUICK about this — otherwise you will lose too much oil from the system. If you are careful, however, just a tiny bit will escape. Now remove the cap from the filler tube. You will have to remove approximately eight ounces of oil from the filler tube to provide a space for the correct volume of air to be applied to the accumulator. You do this by applying air to the accumulator and making sure that you don't get too much air pressure, so that more oil will be displaced than you want to lose.

Replace the cap to the filler line. Put the Schrader valve core back in and supercharge the system by applying air pressure to the accumulator until the low pressure gauge indicates about 25 psi. Replace the dust cap to the Schrader valve and tighten it again.

Unless you want to see what it looks like when a turret blows up, NEVER charge any hydraulic equipment with oxygen, even if the oxygen bottle happens to be handy. A mixture of oxygen and hydraulic fluid creates an EXPLOSIVE combination which can be set off by gunfire or in many cases, by hydraulic pressure alone.

Use a standard hangar air line, if it is available — that is, a regular air hose such as the one found in any gas station. If you are working in a hangar, you are just about sure to see one attached to a compressor.

In case you don't have an air line, you can use an ordinary bicycle or automobile tire pump.

ADJUSTMENT OF TURRET ROLLERS

That just about covers the operation and maintenance of the hydraulic system in the Martin 250 SH–2.

There is one mechanical adjustment you should know about, however, before going on to the next turret. This is the ADJUSTMENT OF THE TURRET ROLLERS.

This isn't difficult. All you need in the way of equipment is one screwdriver and an open-end wrench.

There are three sets of rollers to consider. There's the AZIMUTH variety, on which the turret rides in azimuth on the saddle assembly, as it revolves around the ring track.

Then there are the UP rollers placed on the underside of the saddle structure and rotating against the upper flange of the

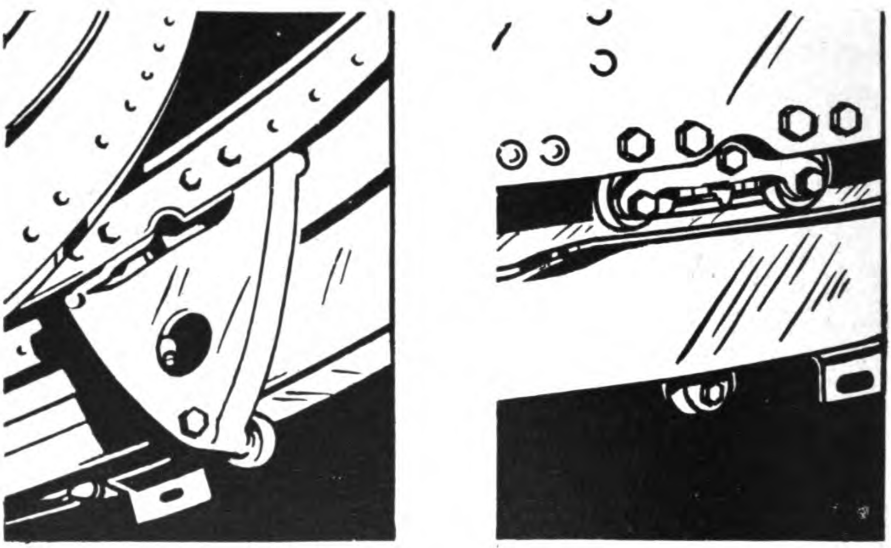


Figure 117.—Section showing rollers.

turret ring. Finally, you have the DOWN rollers, located on the underside of the turret and rotating against the lower flange of the track, or outer turret ring.

If the UP or DOWN rollers are too tight, they STICK. And so will the turret. If they are too loose, the turret can bounce and joggle around in a most disconcerting manner.

Now about the adjustment. All of these rollers are accessible to you and your screwdriver. They all have locknuts — in the case of the AZIMUTH and the UP rollers, these nuts are located above the rollers. In the DOWN rollers, they are below the rollers.

Loosen these locknuts. Now insert the screwdriver in the slot across the top (bottom of the DOWN rollers) of the bolt

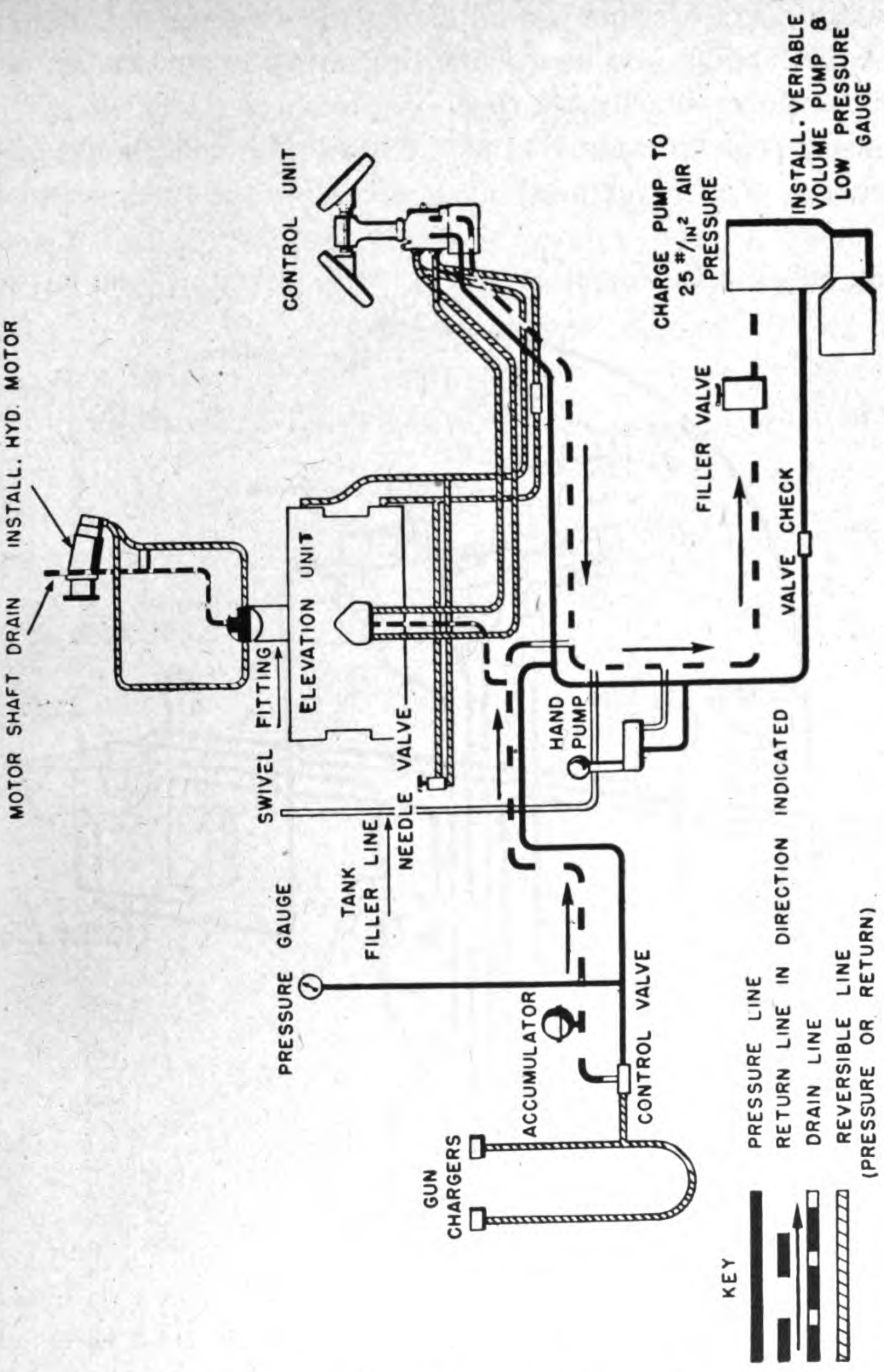


Figure 118.—Hydraulic system, Martin 250 SH-2.

on which the locknut is situated. Turn the screwdriver to the right or left until the RIGHT ADJUSTMENT IS ACHIEVED. What is the RIGHT adjustment? Well, that's something you'll just have to FEEL. Not too tight, not too loose, if that's any help to you.

But don't worry. You'll catch on quick as to what adjustment is the right one after a little experimentation. How the turret operates after you adjust its rollers gives the answer.

One other thing. At least 75 percent OF YOUR ROLLERS should be touching the outer turret ring.

You can FORGET ABOUT LUBRICATION. The rollers are self-lubricating. You never need oil or grease on the track or outer ring, either.

This roller adjustment is IMPORTANT. Even if you've got

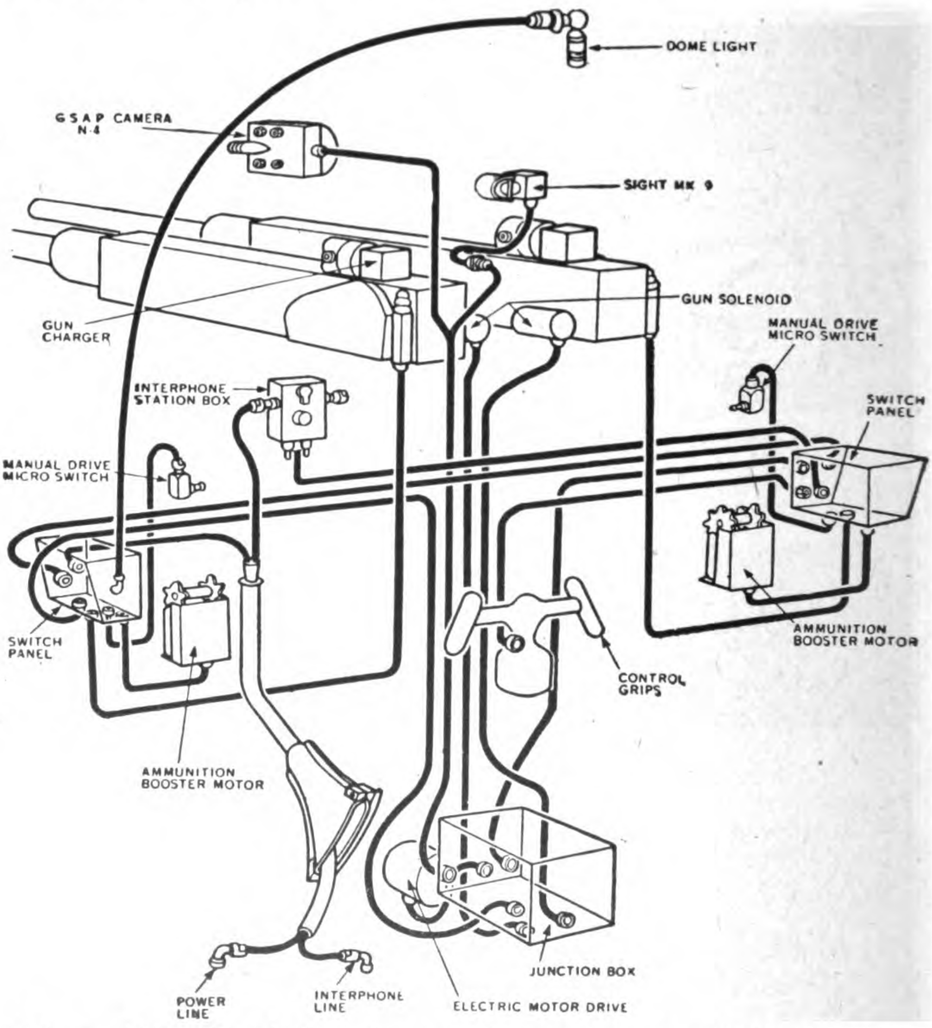


Figure 119.—Electrical equipment diagram, Martin 250 SH–2 turret.

the hydraulic system in apple pie condition, the turret won't perform smoothly if your rollers are out of line.

STUDY THE DIAGRAMS!

Now to top off your investigation of the Martin 250 SH–2 turret, check the diagrammatic hydraulic system shown in figure

118. The numbers enclosed in circles represent the part numbers of the various hydraulic lines and other units which you will want to refer to in ordering replacements or in following lists and diagrams in the Martin 250 SH–2 parts manual.

Remember that even though this Martin turret operates HYDRAULICALLY, it still utilizes ELECTRICITY and a great many electrical units. You will see this very clearly when you look at figure 119, the electrical equipment diagram. Remember, too, that it takes a little electric motor to drive the hydraulic pump which sends the whole hydraulic force into action!

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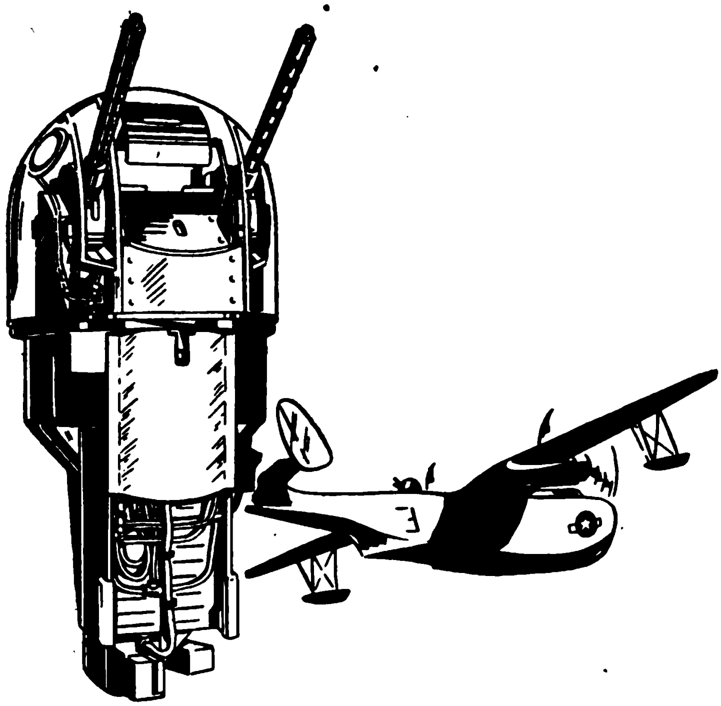


CHAPTER 7

MARTIN 250 CH–3 TURRET

WHAT IS IT?

Now that you are familiar with the Martin 250 SH–2 turret, you have a head start on understanding the operation of the Martin 250 CH–3. The main difference between the two is in their shape.

As the code tells you, the 250 CH–3 is a cylindrical hydraulically operated turret, mounting two .50 caliber machine guns.

You will recall that the CYLINDRICAL turret differs from the SPHERICAL turret in just one way. In the spherical turret, gunner, guns, and sight rotate about a common axis in BOTH azimuth and elevation. However, in the CYLINDRICAL turret, only the guns and sight can be elevated or depressed. The whole turret, including the gunner, rotates in AZIMUTH ONLY, and remains in a horizontal plane when the guns are elevated.

The Martin 250 CH–3 rotates a full 360 degrees in azimuth. The guns may be raised 80 degrees above horizontal and depressed 20 degrees below this level.

You will find this particular model Martin on the upper deck position of the PB2Y Coronado. The Martin 250 CH–1 and CH–2 are almost identical with the CH–3. They are installed

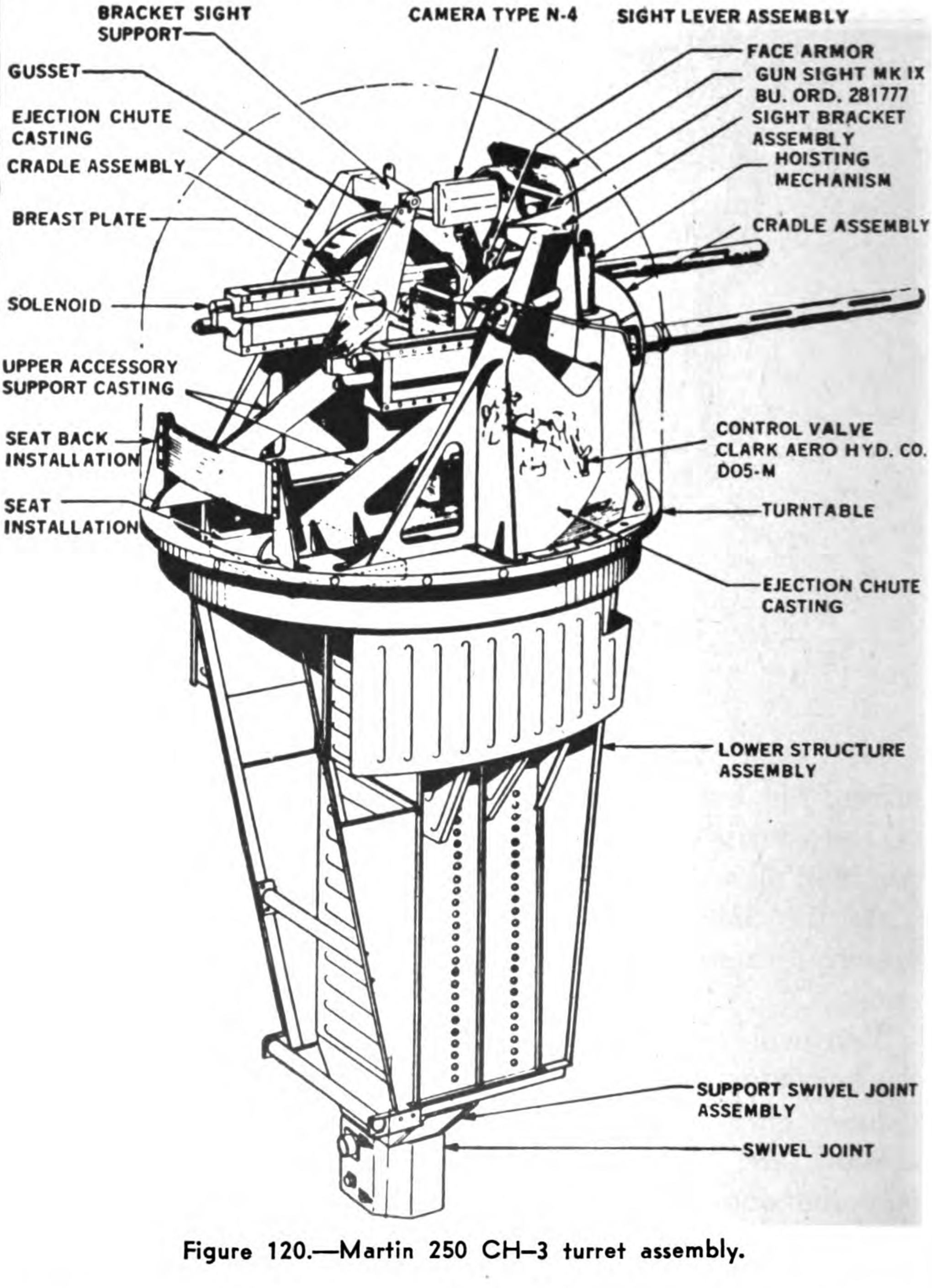


Figure 120.—Martin 250 CH–3 turret assembly.

in various models of the PBM. They operate in the same way, although their rotation in azimuth and their elevation and depression range are more restricted.

The hydraulic system in this turret is almost the same as the one in the Martin 250 SH–2, except for a few distinctive features. Figure 120 will give you a good idea of the Martin 250 CH–3 turret assembly and its parts.

DON'T SHOOT YOURSELF

In this type turret, it is necessary to control the movement so that the guns do not hit or bump any part of the structure of the airplane. That was not necessary in the 250 SH–2, since its position in the bow was such that this problem would not be encountered.

Remember that the 250 CH–3 is located on the UPPER DECK where its guns can easily come down and bounce off or through the fuselage.

Furthermore, you are in a position up there to shoot off the tail or the aft section of the fuselage on your own airplane if you're not careful.

Under the stress of combat, a gunner can hardly be expected to concentrate on shooting down enemies at the same time he

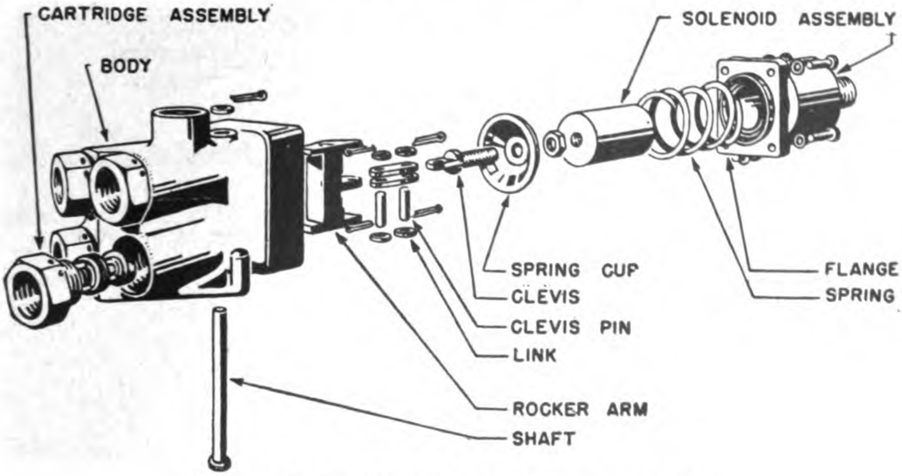


Figure 121.—Structural interrupter valve.

is concentrating on not shooting up the tail section of his PB2Y. So a couple of handy little devices have been designed to keep the guns and the bullets from doing any damage to the home team.

These are known as the STRUCTURAL INTERRUPTER and the PROFILE or GUNFIRE INTERRUPTER. You can see them in figures 121 and 122.

The STRUCTURAL INTERRUPTER is the watch dog which keeps the guns from hitting the fuselage. As you will recall, the lower limit of the guns' traverse is 20 degrees below the horizontal. A cam assembly meshed with the turret drive system is so designed that when this lower limit is reached it puts the STRUCTURAL INTERRUPTER VALVE to work by actuating an electric solenoid. Poppets in this valve reverse the flow of hydraulic

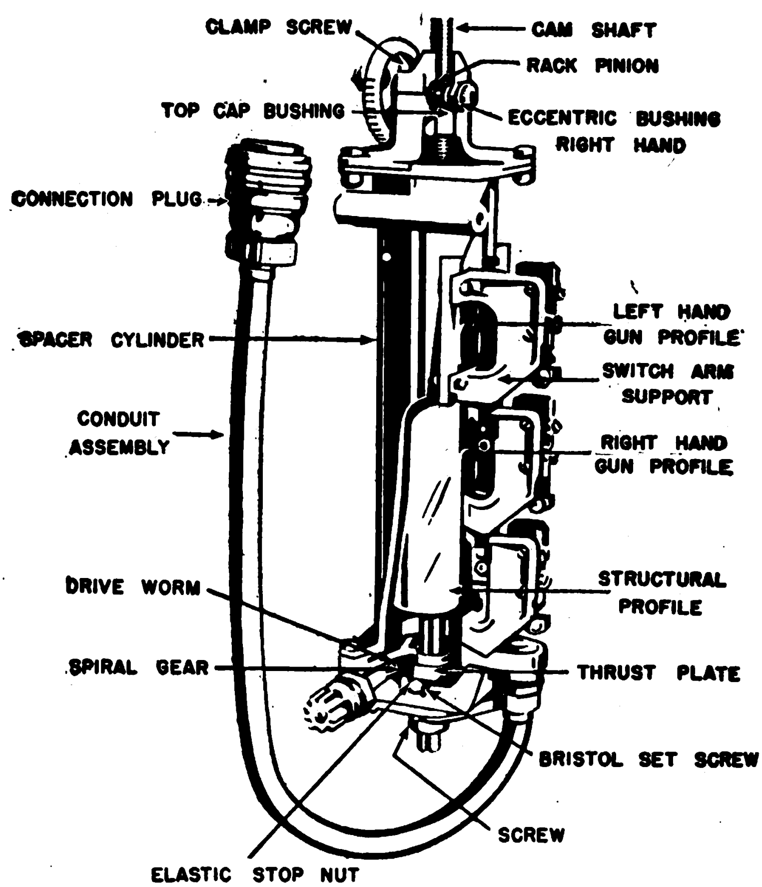


Figure 122.—Gunfire interrupter.

fluid to the elevation motor. This reversal of fluid reverses the elevation motors, causing the guns to lift up before they strike any part of the fuselage.

The PROFILE OR GUNFIRE INTERRUPTER is interwired with the firing mechanism of the guns and is actuated through this same cam assembly. This cylindrical cam is fitted to a shaft which is rotated by the action of a drive piston meshing with the azimuth gear ring of the turret.

There are really three sets of profile engravings on this cam. The one at the TOP carries the outline of the tail and other parts of the aircraft which would come in the line of fire of the left-hand gun. On the CENTRAL PORTION of the cam is an outline of parts which would come in the line of fire of the right-hand

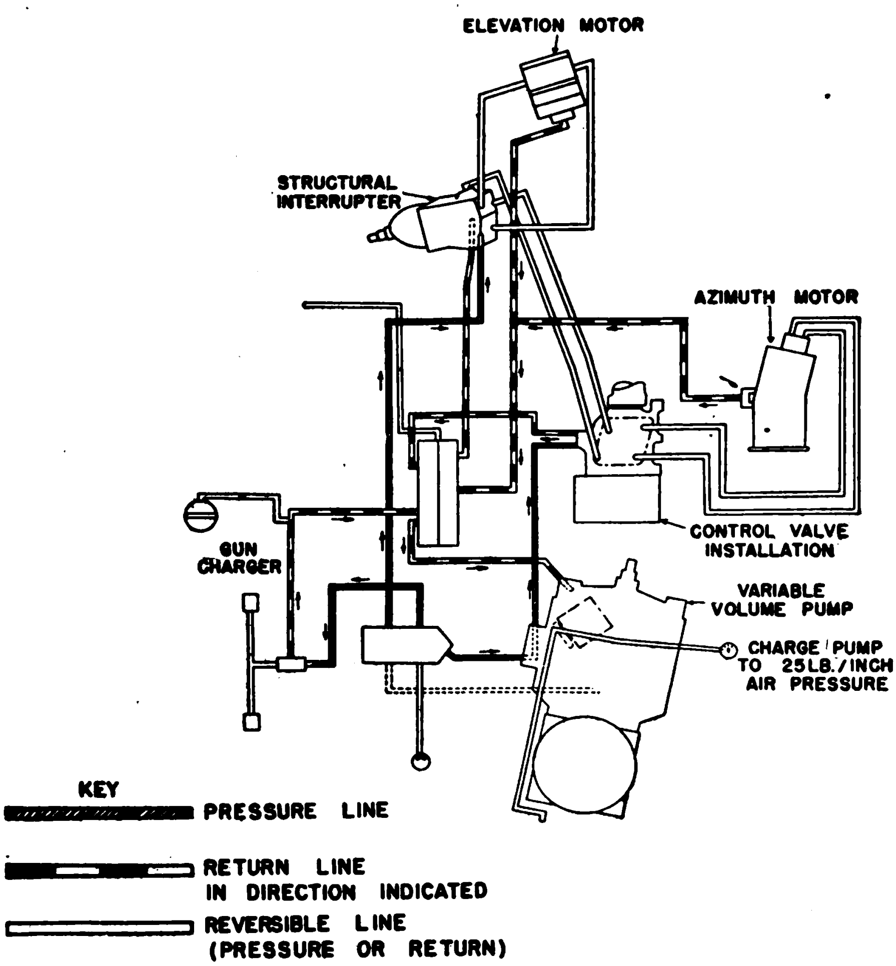


Figure 123.—Hydraulic system, Martin 250 CH–3.

gun. The LOWER PART of the cam is devoted to the structural outline of the airplane and it is this section which causes the structural interrupter valve to do its stuff.

But, as you will note, all three of these insurance policies — the left-hand gunfire interrupter, the right-hand gunfire interrupter, and the structural interrupter — are put into effect by the same cam assembly.

The camshaft is driven by a worm through accurately fitted sliding splines. As the turret rotates, the profile engraving rotates in synchronization with this turret movement. When a point in the engraved outline is reached where the fire from the guns would hit some part of the airplane, little switch buttons press against these outlines. These switches automatically CUT OFF THE FIRE in the particular gun affected — either the right or left-hand gun. And the airplane is SAVED from an ignominious end caused by indiscreet fire from one of its own turrets.

This cam and its shaft are elevated or depressed by an ELEVATION SPUR GEAR meshed with the gear train from the guns. This boosts the cam up and down in synchronization with the elevation or depression of the guns, so that the engraved outline actuating the structural interrupter valve can do its work in the same way.

REPAIRING THE VALVE

You'll be glad to know that complete overhaul and disassembly of the structural interrupter valve is necessary only at rare intervals. Repairs are usually of a MINOR nature.

No adjustment should be necessary, due to the simplicity and efficiency of design and construction of this valve. An occasional drop of oil on the ends of the rocker arms is enough to lubricate it completely.

Here are the repairs you will find easy to make —

TROUBLE: Fluid leaks between cartridge and body

CAUSE	CURE
Cartridge is loose, or	Tighten cartridge.
Gasket under fitting has deteriorated or cracked, or	Replace gasket.
Valve leaks, due to scored seat.	Replace or refinish poppet and/or cartridge.

TROUBLE: Valve does not reverse flow

CAUSE	CURE
Solenoid plunger is out of adjustment, or	Adjust.
Fluid is leaking into solenoid chamber, due to defective seal on poppet stem or cartridge.	Replace defective seal, and clean solenoid.

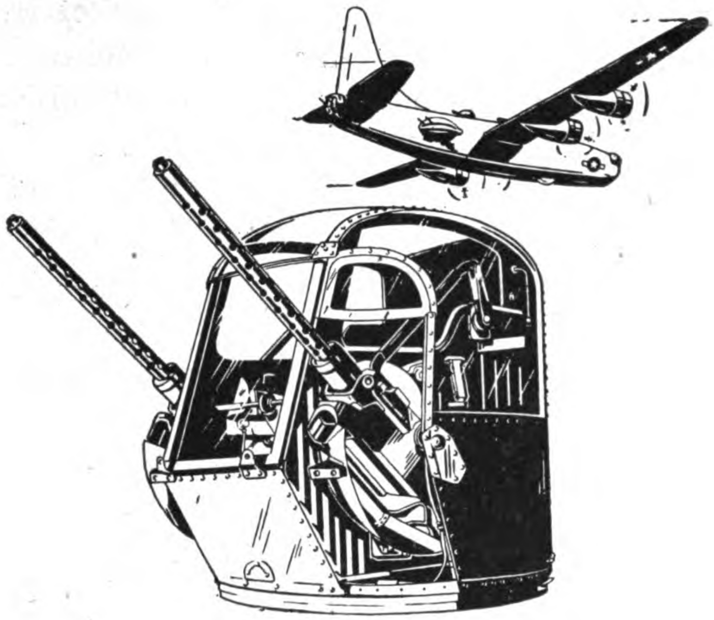
TROUBLE: Solenoid does not operate

CAUSE	CURE
Defective solenoid or electrical connection.	Check wiring or replace solenoid.

Due to the specialized precison work required in construction of the solenoid, it is recommended that you make no attempt to disassemble it, or to repair its component parts.

Since hydraulic systems in the various turrets are almost the same, all the common troubles and their cures are presented in chapter 10.

The Martin 250 CH–3 hydraulic system is shown in figure 123. The electrical equipment on the Martin 250 CH–3 is just about the same as that on the Martin 250 SH–2 (illustrated in figure 119).



CHAPTER 8

MPC 250 CH–5 AND CH–6 TURRETS

FORE AND AFT

These two Motor Products Corporation turrets are designed to man two important posts of duty in the PB4Y–2. The 250 CH–5 guards the NOSE position, while the CH–6 defends the TAIL.

In many Navy models of the PB4Y–2, however, the nose turret is an Erco 250 SH–1 or an Emerson 250 CE–1 or SE–10.

The two MPC turrets are just the same, except that, depending on their position, their rotation is necessarily adjusted. The MPC 250 CH–5 (nose) will rotate in azimuth in an arc of 125 degrees. However, the CH–6 (tail) has a little more room to move around in, and it will rotate a total of 155 degrees.

In both cases the guns will elevate 71 degrees above the horizontal and depress 44 degrees below the horizontal.

The code tells you that, like the Martin 250 CH turrets, the MPC turrets are cylindrical, hydraulic, and mount two .50 caliber machine guns.

MPC turrets are mounted on a circular track built into the nose or tail of the aircraft. A chain segment riveted to a mounting ring on the inside of the track provides the means by which the sprocket mounted in the turret can cause rotation of the turret.

Many of the hydraulic units of the MPC turret are the same as the units you have already become familiar with in previous chapters. However, there are DISTINCTIVE FEATURES that you will want to know about.

Power for rotating the MPC turret and for elevating and depressing its guns is furnished from a HYDRAULIC POWER PANEL OUTSIDE OF THE TURRET in the tail of the aircraft. In other words, this panel is really part of the turret hydraulic system, but unlike the Martin turrets, the MPC does not incorporate this panel within the turret itself. More about this a little later.

The pressure and return lines enter the turret through the SWIVEL JOINT at the bottom center of the turret.

The operation of the turret is controlled by a CLARKE CONTROL VALVE, which you know about. It is the same as on the Martin 250 SH–2 and CH–3 turrets. By operating either or both of the control handles, you can rotate the turret in either direction, and can raise or lower the guns. The controls on both the turret and the guns can be operated simultaneously, making it possible to raise or lower the guns while turning the turret.

The guns are FIRED ELECTRICALLY by means of solenoids which are actuated by squeezing the trigger switches of either or both control handles.

MANUAL CONTROLS are provided to permit operation of the turret by hand in the event of hydraulic power failure. You can fire the guns while operating the turret manually, or, in the event of failure of the electrical firing mechanism, by using the FOOT-FIRING PEDAL.

The turret can be operated from a creep to a speed which will rotate the turret over the complete azimuth travel, while moving the guns from full depression to maximum elevation, in LESS THAN TWO SECONDS. Now take a look at figure 124. It shows the major units which make up the MPC power panel.

LOOKING IT OVER

Earlier in this book you learned about both the constant displacement and the variable displacement Vickers pumps. The MPC uses the CONSTANT DISPLACEMENT PUMP, which is located on the hydraulic power panel rather than in the turret itself. As you may recall, this pump operates just the same

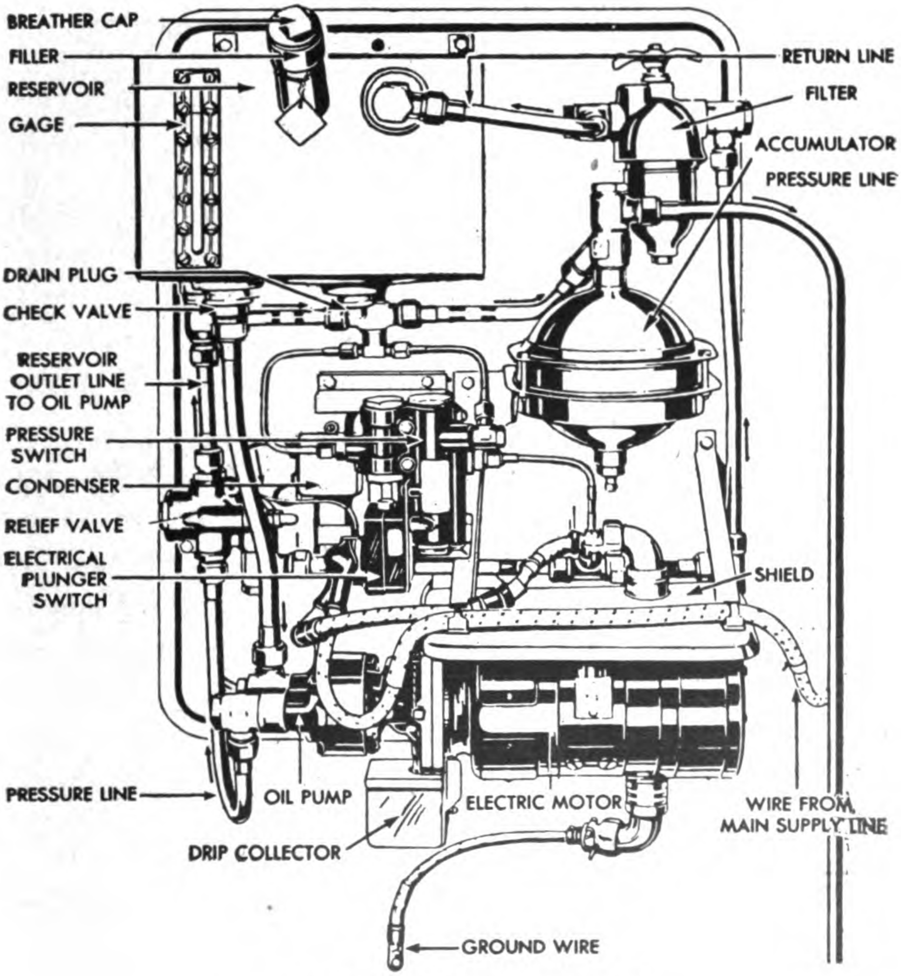


Figure 124.—MPC power panel.

as the variable displacement — that is, its pumping system is the same — except that it does NOT vary the volume of fluid delivered. It pumps the fluid at a constant rate of flow.

The MPC accumulator, similar to the accumulator you studied earlier, is located in the pressure line and stores fluid under pressure to be used when the pump is not operating. The diaphragm can be replaced in case of leaks or damage by unscrewing the two halves of the accumulator and lifting out the diaphragm.

MPC turrets are, of course, equipped with RELIEF and CHECK VALVES, FILTERS, and other hydraulic units about which you already know.

The RESERVOIR on the MPC turret is located on the power panel. It is a rectangular tank of welded aluminum, with a capacity of one and one-half gallons. It holds the fluid supply for operating the actuator. A filler pipe with a breather cap is built into the reservoir at the top. Drainage of the reservoir is by means of a drain plug in the bottom.

Now comes the real HEART of the MPC hydraulic system — the POWER PANEL. The pump, accumulator, and various hydraulic features included within the turret itself in the case of other hydraulic turrets, are located on this power panel. The PRESSURE REGULATOR (unloading valve) maintains pressure between 900 and 1,100 psi.

The fluid flow in the power panel starts when the fluid is taken from the reservoir by the pump and forced through the relief valve to the pressure regulator and on to the accumulator. When the pressure reaches 1,100 psi, the pressure regulator BLOCKS OFF the fluid flow from the accumulator, and the pump volume is bypassed back to the reservoir.

The pressure from the pump drops to approximately 50 psi, while the accumulator pressure remains at 1,100 psi. When the pressure in the accumulator drops below 900 psi, the pressure regulator again functions by closing the bypass line and opening the line to accumulator. The pump pressure almost immediately reaches 900 psi and the accumulator pressure is again built up to 1,100 psi.

From the accumulator, the hydraulic pressure is delivered through the SWIVEL JOINT to the turret to do the work of operating the hydraulic mechanisms. The return line from the turret passes through the filter and into the reservoir. An outlet from the reservoir feeds the pump and completes the cycle.

If the hydraulic pressure switch does not function and the pressure builds up to 1,250 psi, the relief valve acts as a safety valve by opening and bypassing the oil back to the reservoir. When the pump stops, the check valve prevents the oil which is under pressure in the accumulator from back-loading the pump.

THE MECHANICAL PART

The azimuth mechanical control assembly includes the cylinder, rack, gibs, frames, shafts, and gears that convert the hydraulic power in the turret into MECHANICAL DRIVING POWER.

The application of hydraulic power to the cylinder moves the piston, forcing the piston rod in or out of the cylinder. The piston rod is fastened to a rack bar which slides back and forth on two brass strips known as GIBS, mounted on the frame.

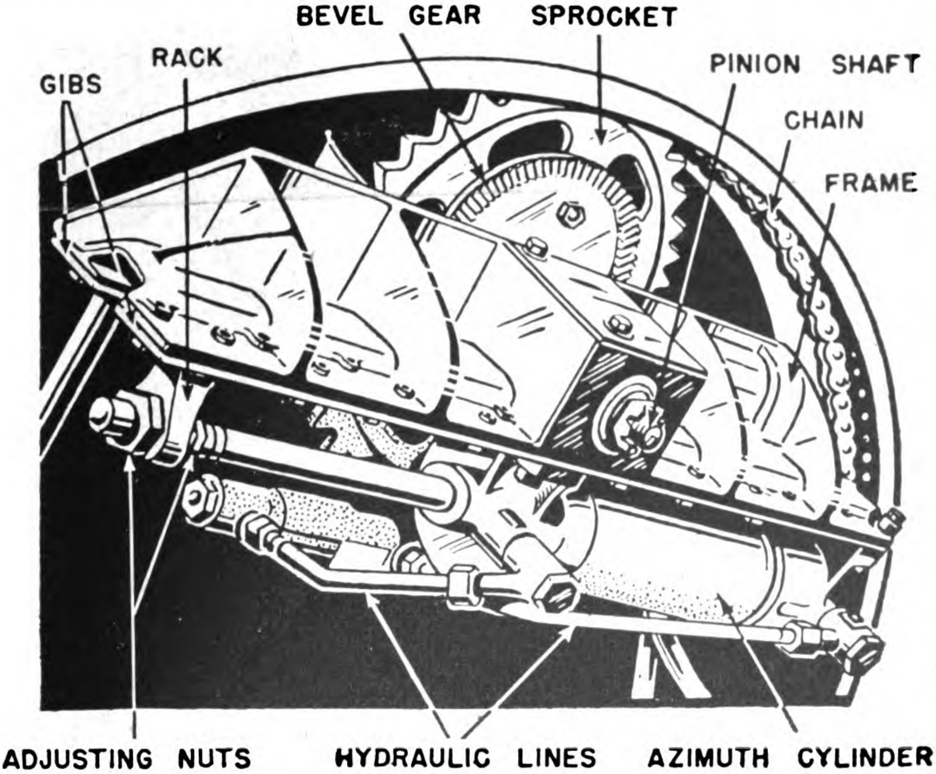


Figure 125.—Azimuth power drive.

The movement of the rack turns the PINION GEAR, which is mounted on the same shaft as two other gears, the BEVEL GEAR and the SPROCKET.

When the turret is installed in the airplane, the teeth of the sprocket mesh into a FIXED CHAIN riveted to the track. When the sprocket turns, it walks around the chain, moving the turret with it.

The assembly is such that moving the PISTON ROD out (by turning the control handle clockwise) moves the rack to the left, turning the pinion and spocket counterclockwise, and also moving the sprocket and turret clockwise along the chain. In other words, rotating the handle to the right turns the turret to the right, and vice versa.

The cylinder used for the AZIMUTH CONTROL unit is a double-acting, single-piston type. The cylinder is threaded into forged

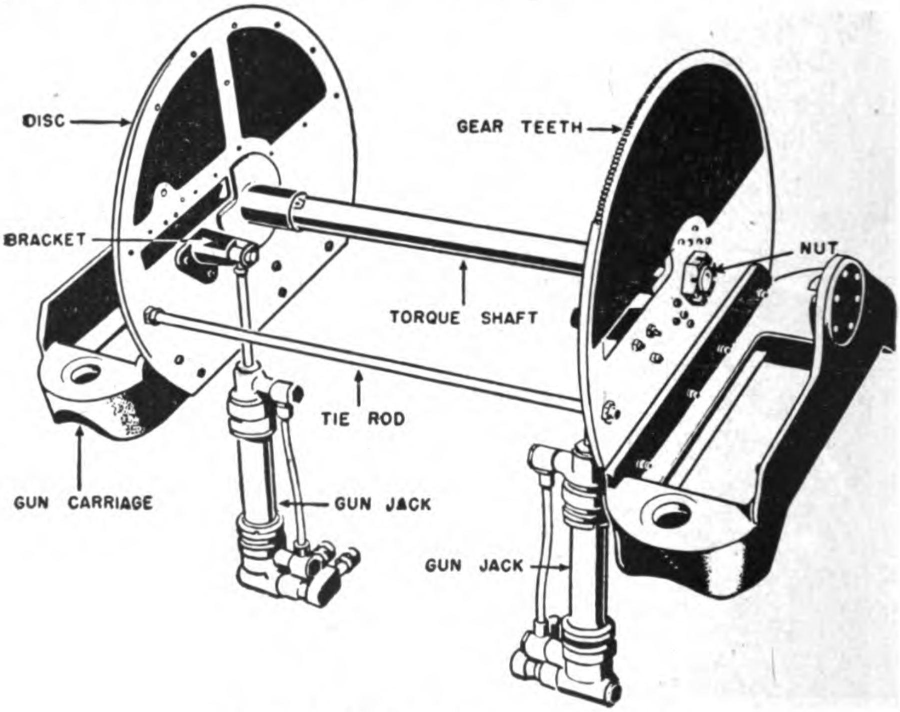


Figure 126.—Elevation control units.

aluminum caps. A neoprene doughnut packing ring in each cap prevents leaks between the caps and the barrel. A port in each cap permits the fluid to enter or leave at each end of the cylinder.

An ARM at 90 degrees to the rack itself, bored for the piston rod, is located at the outer end of the rack. The teeth of the rack are cut to mesh with the pinion gear. A channel is ground on each side of the rack to allow the rack to slide along on the gibs. The position of the rack on the piston rod can be varied by moving the adjusting nuts and washers that are installed on the piston rod on either side of the rack arm.

The two flat bronze strips on which the rack slides are fastened by means of cap screws directly to the frame, and the cylinder is bolted through them to the frame. To get a better idea of how the azimuth mechanical control works, take a look at figure 125.

How about the elevation movement? This is accomplished by two HYDRAULIC JACKS — one for each gun. Both jacks are

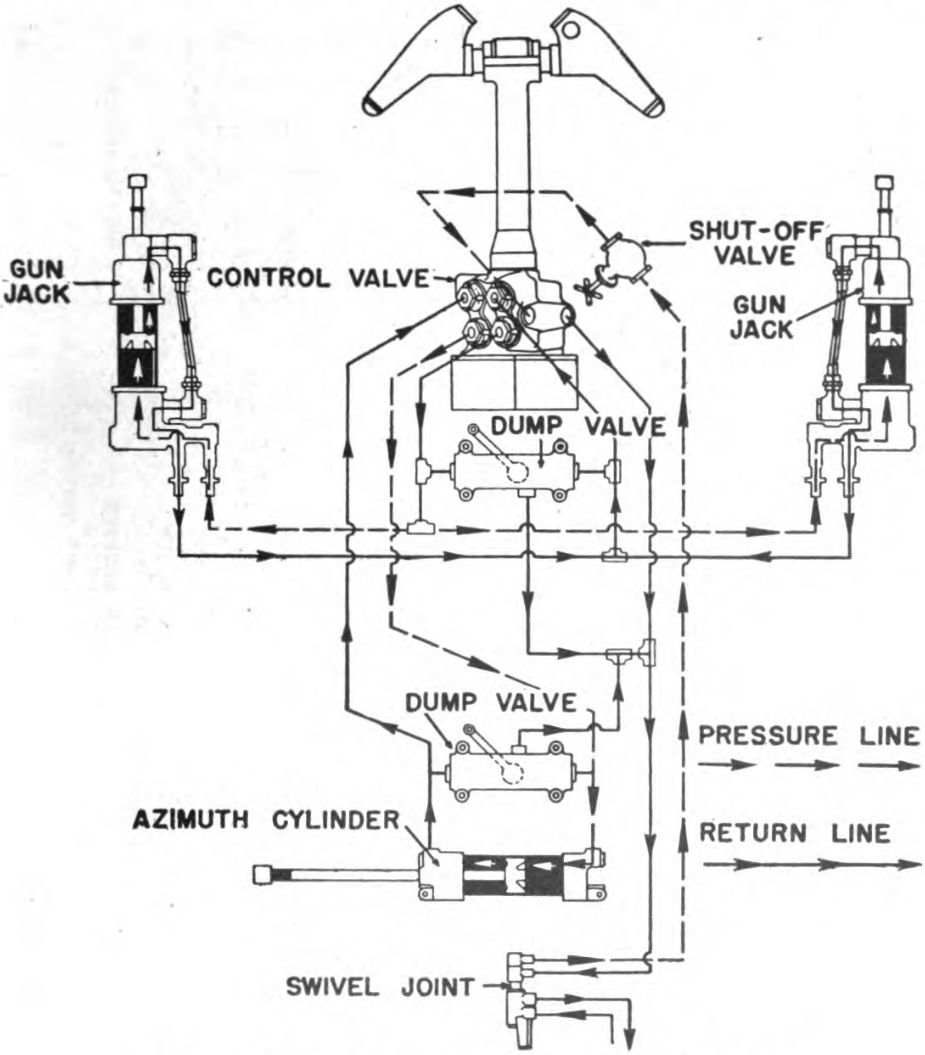


Figure 127.—Hydraulic system, MPC CH–5 and –6.

operated by the same two hydraulic lines so their action is identical.

These jacks are anchored in a vertical position by swivel joints at the bottom and outer side of the cross-beam assembly

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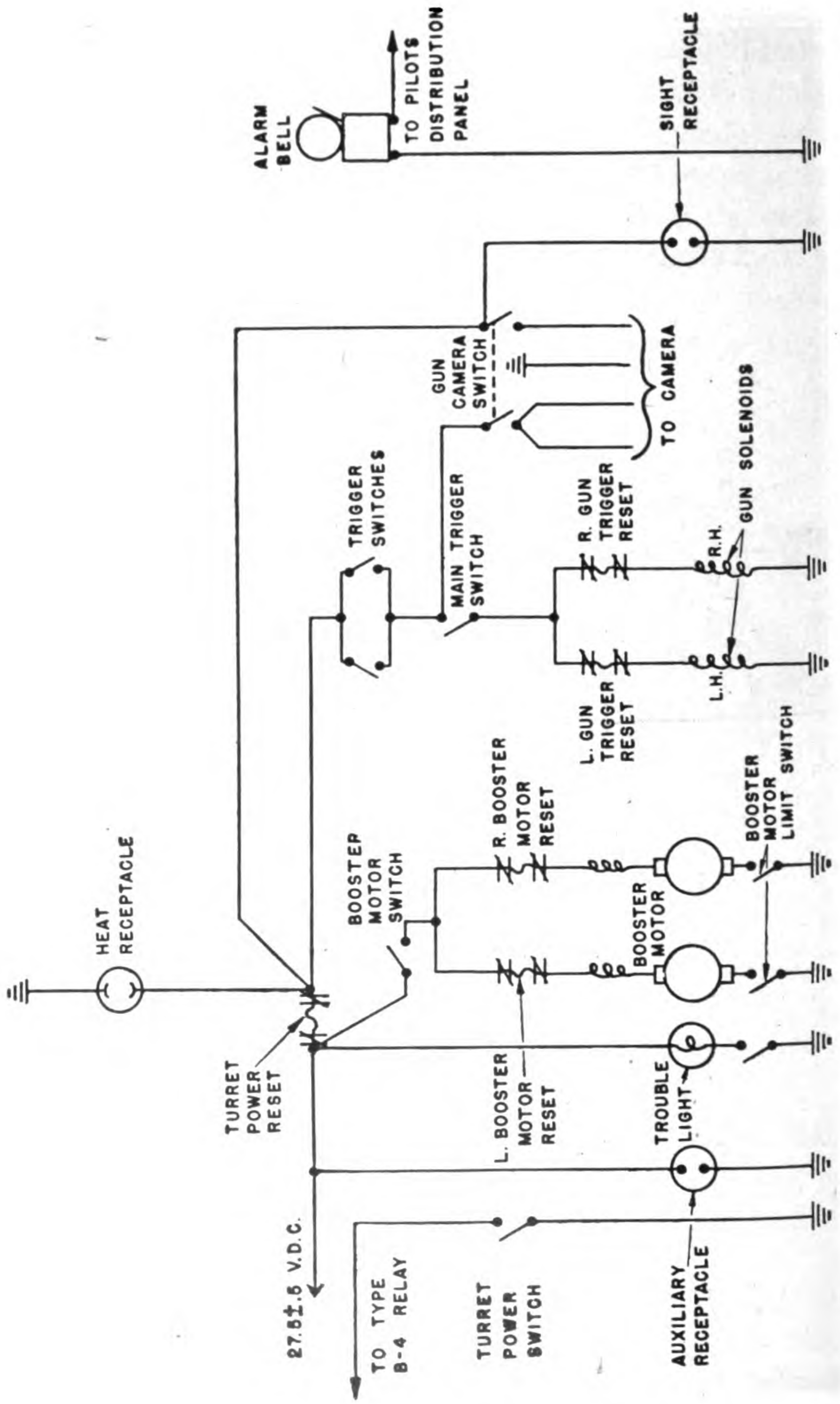


Figure 128.—Wiring diagram, MPC 250 CH–5 and –6.

Piston rods in the jacks work against the bracket which is bolted to a disk assembly attached to the gun carriage.

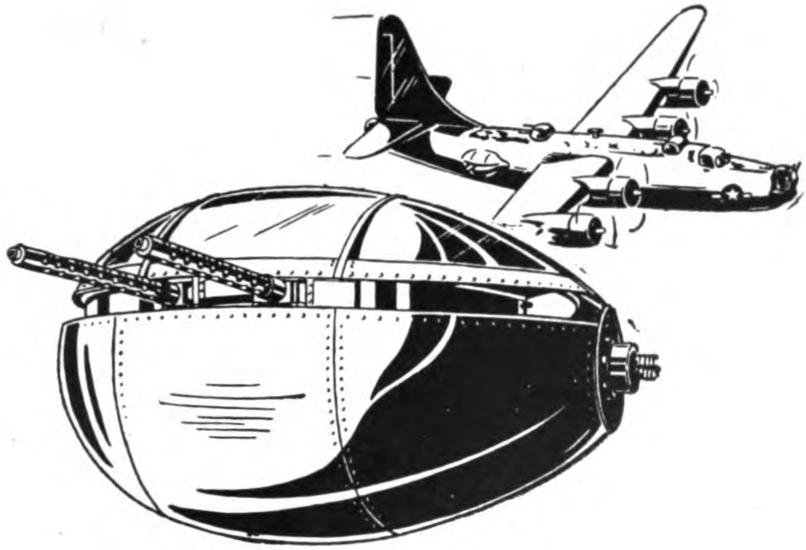
When fluid is forced against the bottom of the piston, the piston and rod go up. So do the guns. Reversing the fluid flow depresses the guns.

A swivel joint on the same general design as the swivel joint between the turret and the aircraft furnishes the connection between the jack and the lines, regardless of the changing angle of the jack.

The actual construction of the jack is just about the same as that of the azimuth cylinder. You will recall that you learned about the action of the hydraulic jack as the first example of an operating system, and it really is a very simple mechanism.

To see the location and general appearance of the elevation control units, study figure 126.

You'll find a diagram of the MPC hydraulic system in figure 127. A wiring diagram for this turret appears in figure 128. The figures next to the various units are part numbers used in ordering MPC replacements.



CHAPTER 9

ERCO 250 TH–1 AND TH–2 TURRETS

THE TEARDROP

Erco 250 TH turrets are streamlined to the approximate shape of a TEARDROP.

The TH–1 is installed in the STARBOARD side of a PB4Y–2, while the TH–2 matches it on the PORT side. With their wide cone of fire they protect the airplane from beam or belly attacks, besides covering a considerable area above the aircraft.

In the teardrop, you will recall, the gunner moves with his guns and sight in BOTH AZIMUTH AND ELEVATION. In azimuth, the teardrop will move the guns 55 degrees toward the bow from a beam position and 80 degrees toward the tail from beam. The guns can be elevated 55 degrees above horizontal and depressed 95 degrees below horizontal.

The main thing which distinguishes the Erco from a Martin 250 SH–2 and the CH turrets is the shape. The hydraulic system is made up of units you have already learned about.

These include a VICKERS VARIABLE DISPLACEMENT PUMP and a CLARKE CONTROL VALVE assembly with control handles, gun firing TRIGGERS, and SWITCHES.

The motivating power, both in azimuth and in elevation, is provided by hydraulic CYLINDERS mounted on PISTON RODS. The

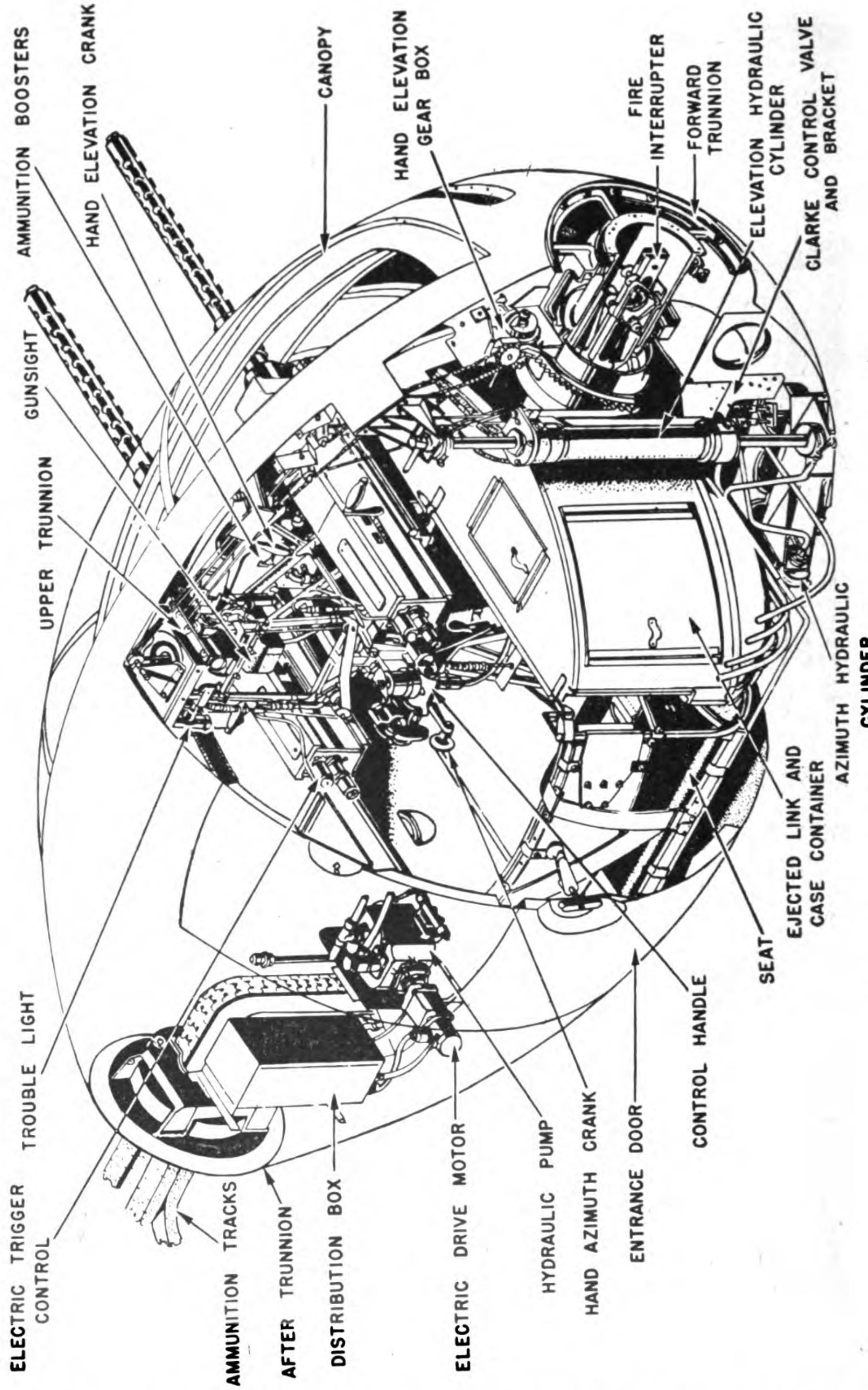


Figure 129.—Cutaway view of Erco 250 TH turret.

azimuth rotation cylinder is secured to the bottom structure of the turret. The elevation cylinder is secured to the turret structure at each end.

These cylinders are BALANCED. That is, the cylinder area is the same on each side of the piston.

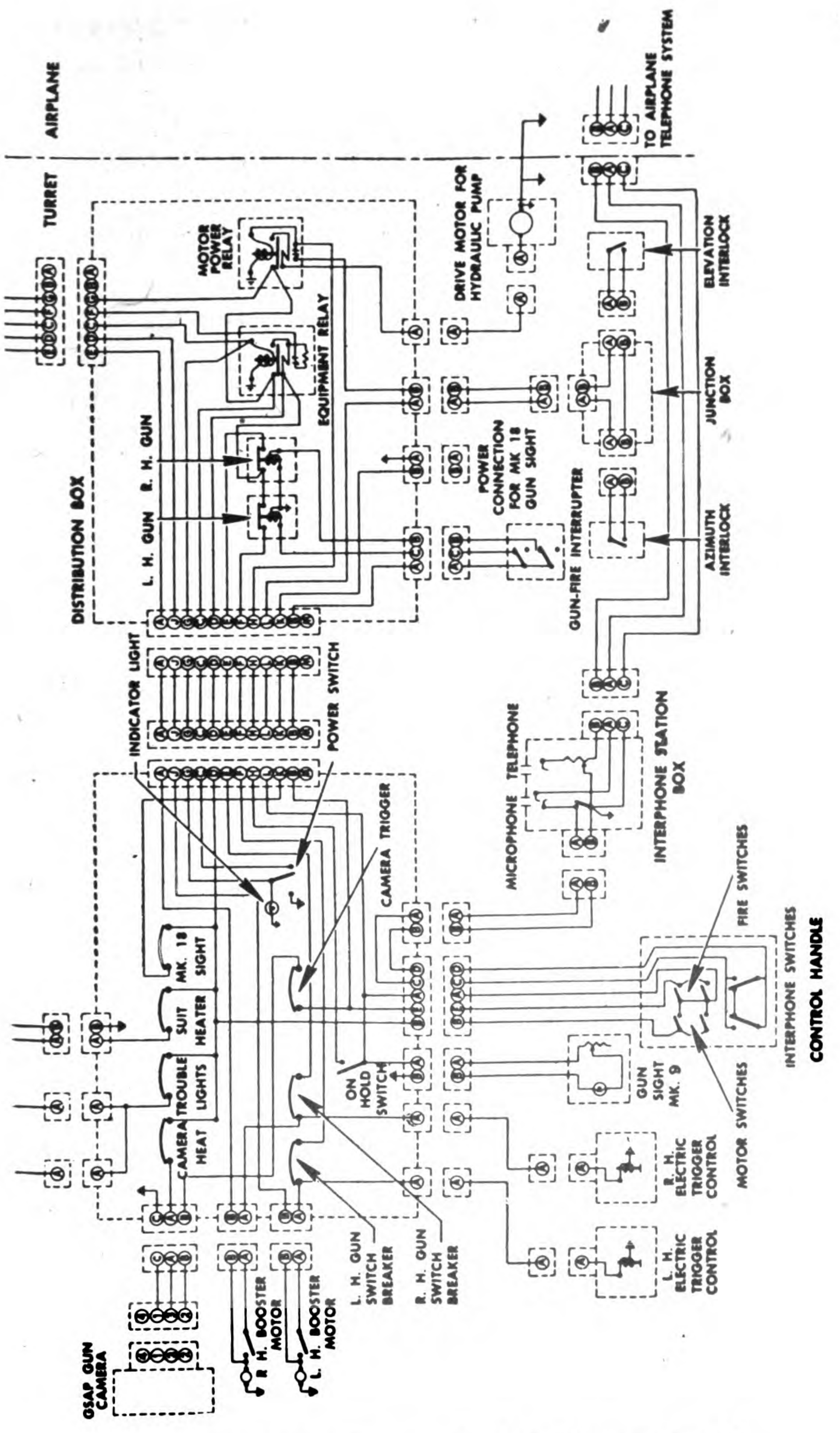


Figure 130.—Wiring diagram, Erco 250 TH–1 and TH–2.

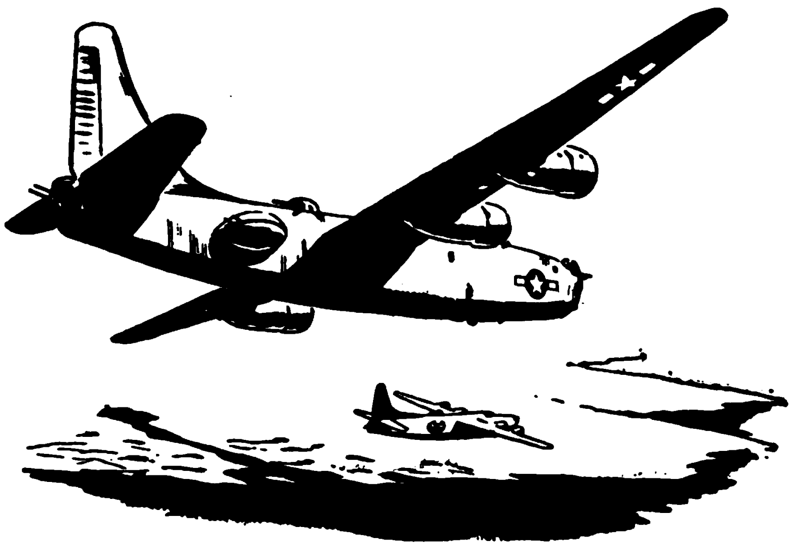
Take a look at the schematic of the Erco TH hydraulic system, and it will be easy for you to follow through its operation. This was illustrated in figure 107.

NO ACCUMULATOR

You will notice that there is NO ACCUMULATOR in the turret. Since hydraulic gun chargers are not used in this turret, the amount of fluid in the system is balanced throughout. On the Martin turrets, when the hydraulic charger is used, the accumulator is necessary to refill the system when the gun chargers (unbalanced cylinders) are operating and using part of the system's fluid.

The Erco is equipped with a GUNFIRE INTERRUPTER, operating on the same principle as the one you read about in the chapter on the Martin 250 CH–3. As in other turrets, the gunfire interrupter cuts off fire when the guns are pointed into the airplane. But in the case of the teardrop, the gunner is usually warned NOT to rely fully upon his interrupter. Exact adjustment is difficult, due to various factors which we don't have to go into here.

Before you study Erco TH troubles and their cures in the next chapter, take a good look at the Erco hydraulic system and the wiring diagram in figures 107 and 130, respectively.



CHAPTER 10

TROUBLESHOOTING

ANALYZING HYDRAULIC TURRET FAILURES

Fortunately for you and for anyone else who wants to TROUBLESHOOT hydraulic turrets, turret failures follow a common pattern. This is due to the fact that the SAME BASIC UNITS make up the hydraulic systems in the various turret models.

As you have already found out, the Martin 250 SH–2, the Martin 250 CH–3, and the Erco 250 TH–1 and TH–2 all depend on the VICKERS VARIABLE PUMP for hydraulic power. For that matter, so do the Martin 250 SH–1A, the Martin 250 CH–1 and CH–2, and the Erco SH–2, 2A, and, 3.

All of these turrets use the CLARKE CONTROL VALVE. All of them, except the Erco, are equipped with ACCUMULATORS of the same type. In each of these turrets a RESERVOIR system, RELIEF VALVE, and COMPENSATING (pressure control) VALVE are incorporated within the pump case. They all use the same hydraulic FLUID and similar LINES, VALVES, and FITTINGS.

The MPC 250 CH–5 and CH–6 has a few variations which distinguish this type of turret from those of other manufacturers. First of all, it operates from a POWER PANEL which is mounted on the bulkhead of the airplane rather than in the turret. It uses a Vickers CONSTANT DISPLACEMENT PUMP, and it is actuated by hydraulic CYLINDERS rather than by hydraulic motors. However, it also employs a Clarke control valve, an accumulator, and other features found on the other hydraulic turrets.

So, in presenting descriptions of troubleshooting to make it easy for you to analyze difficulties and know how to eliminate them, you can consider these hydraulic turrets together—

Martin 250 SH–1A, 2, 2A
Martin CH–1, 2, 3
Erco 250 SH–2, 2A, 3
Erco TH–1 and 2

They will be considered GROUP 1 turrets in the lists to follow. Then you can consider the Motor Products Corporation turrets separately (as GROUP 2) in the lists. Here's the line-up.

ELECTRICAL FAILURES

TROUBLE: Relays or switches not operating

CAUSE	GROUP	CURE
First, make sure they are receiving current. If so, see if they are sticking or burned out.	1 & 2	Clean or replace.

TROUBLE: Motor overheated

CAUSE	GROUP	CURE
Poor connection, or	1 & 2	Check all motor connections and clean wires or contacts when necessary.
Motor is overloaded. This may be because compensator in Vickers pump may not be functioning and allowing pump to operate at full volume against high pressure. If the pump is excessively hot, this is probably the cause of the trouble, or	1	Replace pump.
Hydraulic pressure regulator may be stuck, thus passing fluid over the system relief valve, or	2	Replace regulator.
There is internal motor trouble.	1 & 2	Don't try to repair motor—replace it.

TROUBLE: Control handle fails to produce desired response

CAUSE	GROUP	CURE
Wires breaking when handle moves.	1 & 2	Rewire and leave sufficient slack. Also make sure wiring will not rub through.
Action (dead man) switch shorting out.	1 & 2	Replace switch.

HYDRAULIC FAILURES

TROUBLE: Pressure will not build up

CAUSE	GROUP	CURE
Oil level is too low, or	1 & 2	Add AN–VV–O–366 oil to the proper level for system.
	1	Bleed system and check to be certain housing is full. Relieve supercharge pressure before opening system.
	2	Relieve all hydraulic pressure BEFORE filling.
Pump isn't working, or	1	Remove back cover of pump and check position of yoke. It should NOT be in the center. If it is, check linkage to see that it is connected. Also check the large compensator spring to see if it is broken. With the compensator disconnected, the yoke should swing freely. If it does not, the pintle seals are blown. If damage is at all complicated, do not attempt to repair it, but replace the pump. Send the old pump to an authorized overhaul point.
	2	Remove the pump and replace with a new pump, sending the old pump to an authorized overhaul point.
Relief valve is set too low, or	1	Remove back cover and remove relief valve assembly from valve plate. Check ball, ball seat, and
	1	spring. Replace with new valve if necessary.
		Check hydraulic pressure regu-
	2	lator. If this is not functioning, replace.
There is internal leakage, or		With controls in neutral, check for internal leak. Use the hand

CAUSE	GROUP	CURE
		pump in the case of Martin 250 SH–1A, 2, and 2A. In other Group 1 turrets, supercharged pressure should be released so you can check the return line for flow. Replace leaking units.
	2	With controls in neutral, and star valve open, check flow for internal leakage. Replace leaking units.
Control valve is improperly adjusted.	1 & 2	Correct any adjustments which need attention. If the cage is IN too far, it causes tightness and will slow operation in the opposite direction. If the cage is OUT too far, it causes loose play and slow operation in the same direction. One cage in and one cage out too far causes rapid operation toward the cage that is in too far.

NOTE—Low pressure may sometimes be due to deficient voltage supply from electrical system, causing the electric pump to operate slowly.

TROUBLE: Air in system — turret operates erratically or not at all

CAUSE	GROUP	CURE
System not properly bled, or	1	Refill system and bleed.
	2	Run the turret to eliminate air in system.
Oil viscosity is too high, or	1 & 2	If AN–VV–O–366 hydraulic fluid is not available, Army Spec. 3580 or Navy Spec. M–399 oil will be adequate substitutes. Other fluids should not be used.
Diaphragm is ruptured.	1	Remove back cover and replace diaphragm that is ruptured.
	2	Not affected.

TROUBLE: Turret moves more quickly in one direction than in the other

CAUSE	GROUP	CURE
Incorrect adjustment of control valve.	1 & 2	Valve cage controlling the action which produces faster action should be backed out and slow valve cage turned in until valve action is equalized.

TROUBLE: Excessive play of handles in neutral

CAUSE	GROUP	CURE
Incorrect valve adjustment, or	1 & 2	Valve cages are turned out too far. Turn them in to reduce neutral play.
Looseness or wear in elevation linkage, or	1 & 2	Disassemble valve and check for play in linkage.
Looseness or wear in azimuth linkage.	1 & 2	Disassemble valve and check for play in linkage.

TROUBLE: Stiffness in elevation handle control

CAUSE	GROUP	CURE
Torque tube bearing nut too tight.	1 & 2	Loosen bearing nut to relieve overload.

TROUBLE: Turret fails to hold

CAUSE	GROUP	CURE
Leakage in lines, or	1 & 2	Check for leaks and correct.
Dump valve does not seat, or	1 & 2	Remove valves and clean. Check springs and replace if weak or broken.
Control valves fail to seat, or	1 & 2	Remove valves and clean. Replace valves if spring is weak or broken.
Cylinder fails to hold, or	1	Not affected.
	2	Disassemble cylinder and replace piston packing. Check packing on gun jack swivel. If packing is undamaged, disassemble actuating cylinder, replace piston packing.
There is air in cylinders.	1	Not affected.
	2	Bleed by operating turret.

MECHANICAL FAILURES

TROUBLE: Turret binds mechanically

CAUSE	GROUP	CURE
Maladjusted rollers, or	1 & 2	Check rollers and readjust where sticking occurs.
Misalinement or bent equipment, or	1	Check hydraulic motor alinement. (In Martin 250 SH turrets, check Parker elevation units for alinement.)

CAUSE	GROUP	CURE
	2	Check hydraulic cylinder rods.
Broken or jammed roller, or	1 & 2	Locate roller that is not turning, and replace.
Roller attaching bolts too long.	1 & 2	Remove bolts that are rubbing and install bolts of correct length.

TROUBLE: Restriction in turret movement at localized spot

CAUSE	GROUP	CURE
High spot in track.	1 & 2	Machine track to true level, or replace track.

TROUBLE: Play or rock between turret and aircraft

CAUSE	GROUP	CURE
Hold-down rollers out of adjustment, or	1 & 2	Readjust to eliminate play between rollers and track.
In the Erco TH turret, trunnion mount, and bearings need replacement.	1	Replace.

HERE'S A TURRET CHECK-OFF LIST

If something's fouled-up on an airplane, the best time to find it out is ON THE GROUND.

That goes for turrets, too. Checking the turrets before each flight is ROUTINE. Who wants to find out when he's up in the air that he's parked behind broken-down equipment? Not you or anyone else.

You can use the check-off list which follows as a guide for pre-flight inspection. It covers all types of turrets, both electric and hydraulic.

Consider it sort of a "physical examination" form. It will help you make sure that turrets you inspect — or ride in — are really UP TO PAR and READY TO FIGHT.

PLANE (model)......TURRET (model)......DATE.........
Serial No.............Serial No.............

DOME

( ) Inspect for cracks, holes, scratches, and oil film.

( ) Inspect hold-down or attaching bolts for tightness, defects, and proper safetying.

( ) Check ventilator and escape hatch for freeness of movement and ease of release.
( ) Inspect slot curtain(s) and weather seal(s).
( ) Inspect dome reinforcements.

TURRET STRUCTURE AND COMPONENTS

( ) Check guide rollers for freeness of movement and guide roller track for chafing, grit deposits, and excessive wear.
( ) Inspect load and stabilizing roller mounting studs for tightness and safetying.
( ) Check elevation and depression limit stops for security and proper adjustment.
( ) Inspect gunfire protector for cracks, dents, and security.
( ) Inspect foot rest.
( ) Inspect main casting or turret structure for rigidity, cracks, and cleanliness.
( ) Inspect seat for security and proper adjustment, and the latch mechanism for freeness of release.
( ) Inspect azimuth ring for grit deposits, chipped or cracked teeth, and security of mounting bolts.
( ) Check gun carriages for freeness of movement, broken studs, chipped teeth, and parallel alinement.
( ) Check torque tube assembly for security and for general condition of gears and bearings.
( ) Inspect shock absorbing device(s) and gun adapter(s) for security, adjustment, and cleanliness.
( ) Inspect safety belt for security and for general condition of belt and buckle for latching and releasing.
( ) Inspect collector or slip ring for cleanliness, security, general condition of power terminals, and of power and ground brush assemblies.
( ) Inspect oxygen bottle installation for security, valve position, swivel joint, and condition of tubing.
( ) Inspect ammunition containers for cracks, quantity of ammunition, and safetying.
( ) Inspect sight cradle for cracks, adjustment, alinement, and safety.
( ) Check controller box for proper deflection, adjustment of stops, ease of movement, and security.

( ) Check trunnions for freeness of movement, security of end frames, proper lubrication, and excessive wear.

( ) Inspect expended clip and shell box for cracks, dents and safetying.

( ) Inspect all safetying and bonding on complete turret.

POWER AND DRIVE UNITS

( ) Inspect amplidynes for broken studs or bolts, proper safetying, and general condition of cannon plugs.

( ) Inspect turret drive motors for security, ease of engaging and disengaging of hand clutch; check drive pinion backlash and general condition of drive pinion.

( ) Inspect junction box(es) and turret harness for security, position of switches, general condition of conduit, and cannon plugs.

( ) Check position and adjustment of switch(es) and operating mechanism(s) on complete turret.

( ) Check line contactors for proper functioning, and inspect contacts for burning and pitting.

AUXILIARY CIRCUITS AND UNITS

( ) Inspect ammunition feed assistor(s) for proper safetying and alinement, and check for proper operation.

( ) Check ammunition feedway(s) and extension spring(s) for proper tension, movement, and security.

( ) Check fire interrupter assembly(ies) or switch(es) for proper opening and closing, correct alinement, and proper safetying; inspect cam(s) for security.

( ) Check contour follower for proper operation, adjustment, and safetying.

( ) Inspect communications system for general condition, proper safetying, and security.

( ) Check gun selector switch(es), firing switch(es), and manual trigger for position.

( ) Check trouble light and suit heater rheostat for proper operation and security.

HYDRAULICS AND UNITS

( ) Check neutral tolerance for controller.

( ) Check azimuth limit stops for proper adjustment and security.

( ) Check all tubing and fittings for leaks, dirt deposits, and proper securing.

( ) Check all swivel joints and packing nuts for safetying and leaks.

( ) Check fluid level, and clean filters.

( ) Inspect gun charger system for leaks, security, valve position.

( ) Check manual shut-off valve(s) for proper operation and leaks.

( ) Check manual systems and hand pump for proper operation.

( ) Inspect all flexible hoses and hose clamps for leaks, kinks, safetying, and cleanliness.

( ) Check accumulator pre-load pressure.

( ) Check pump supercharging pressure.

( ) Check operating pressure.

( ) Check relief valve(s) setting.

( ) Inspect cable and azimuth winch drive for proper adjustment, frayed cable, correct winding on drum, and safetying.

OPERATIONS TEST

1. Turn on emergency or pilot's power switch.
2. Test booster motor(s).
3. Test amplidynes or hydraulic generator drive motor.
4. Test oxygen and communications system.
5. Test trouble light and sight lamp.
6. Test turret for compounding or creep.
7. Test turret operation in azimuth or train.
8. Test turret operation in elevation.
9. Test suit heater system.
10. Clean dome or enclosure.

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Number or rounds of ammunition aboard..................

I certify that this turret has been inspected under by supervision as indicated above and that the turret (is) (is not) in condition for flight.

Date........ Turret Captain........................

Bu. No.............

I accept this turret for flight.

Gunner........................

(TO BE FILLED OUT AFTER FLIGHT)

During flight, I have noticed the following defects in this turret which should be remedied before the next flight:

1. —
2. —
3. —
4. —

Gunner................

CHAPTER 11

BORESIGHTING TURRET GUNS

HIT 'EM WHERE IT HURTS

There is an old American custom of SHOOTING WHERE YOU AIM, and a very good custom it is. However, it is an inescapable fact that if you are firing a machine gun from a moving airplane, YOUR BULLETS DO NOT GO WHERE YOU POINT YOUR GUN.

This is true because when you are flying in a bomber you are traveling at high speed. Usually, your target is, too. And your target may be moving in the opposite direction, the same direction, or at any angle between those two directions.

Don't worry about this, though. In the first place, you will find that the Navy has a handy little helper for you to compute automatically all these variables which have to be taken into account before your bullets will land where you aim them. This is the MARK 18 GUN SIGHT. It will be discussed in more detail later in this chapter.

Before your Mark 18 sight can work — or, for that matter, any type of gun sight — your guns will have to be boresighted WITH THE SIGHT YOU ARE USING.

Boresighting is just what it sounds like — sighting through the bore of a gun to get the right alinement. It establishes the necessary relationship between the LINE OF FIRE and the LINE OF SIGHT. Obviously, if your gun is pointing one way and your sight another, you might as well throw the sight away for all the good it will do you.

CLOSE HARMONY

Another consideration in boresighting 250-type turrets is to harmonize the two guns so that the line of their fire will CONVERGE where you want it to, and so that each gun will be set at the proper relationship to the other and to the sight.

There are a number of ways to harmonize guns and sights in the various types of turrets. The exact procedure will have to be defined by your squadron gunnery officer, since a good many considerations peculiar to a particular squadron must be taken into consideration.

Just for example, the range at which your line of fire will converge very often will be determined by the type of mission you are engaged in, the type of airplanes the enemy is using against you, the probability of encountering anti-aircraft fire, and lots of other factors.

Boresighting IS important. Figure 131 (*A* and *B*) indicates that.

Now for the actual boresighting. Assuming you are on land, you will start out by rotating the turret so that it faces sideways in the airplane and so you can sight on "infinity." In other words, you should have a clear, unobstructed view for at least 1,000 yards or more. Then peek through your sight and get a "bead" on a target 1,000 yards or even a mile away. A tree, a chimney or a small shack, or anything you can get a good squint at on the horizon, will work out satisfactorily. Figure 132 illustrates this.

Of course, if you are aboard a carrier, your procedure in boresighting will be different, and it will be decided by the gunnery officer. The only Navy turret at present which you would be boresighting on a carrier is the Grumman. Carrier boresighting usually involves the use of a TEMPLATE or PATTERN which takes the place of a distant, fixed boresight target.

On land, after you have drawn your bead on a distant object, the next step is to remove the back plates and bolts from both guns so you can peek through the barrels. If you have a boresight tool, you can look through the gun barrels without remov-

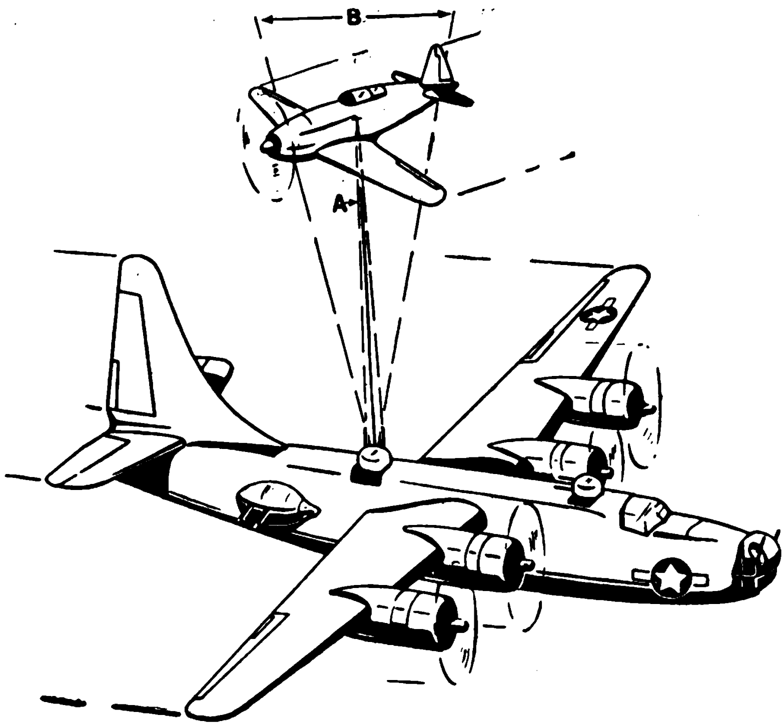

Figure 131.—A hit or a miss.

ing the parts. Now turn the turret manually until the guns point at the object you have selected.

Make sure the sight dot is squarely on the object, once again using elevation and azimuth hand cranks to move the turret, DON'T MOVE THE TURRET AGAIN.

Now boresight through each gun barrel to line up the guns. Adjust each gun by its rear hand adjustment bolts so that the

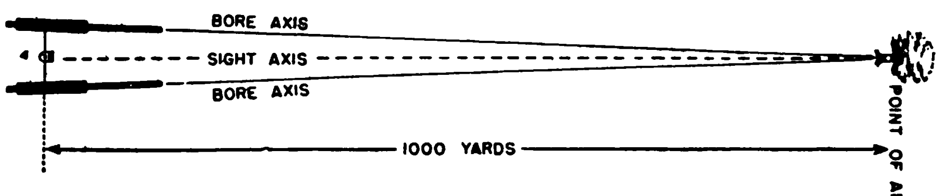

Figure 132.—Boresighting on a distant object.

spot the sight is centered on is exactly in the center of each gun bore.

That is all boresighting boils down to — adjusting the guns so that their line of fire conforms exactly to the line of sight.

Sometimes the amount of adjustment possible in the rear mounts of the guns may not be large enough to bring the guns to bear on the object. In that case, boresight each gun independently on the small object selected. Then you must make an additional adjustment on the sight head, to line up the dot of the sight on the same object.

As you know, the pull of gravity on any bullet causes it to drop off somewhat from the point at which you aim the gun. However, whether you are pointing the gun up or down has a definite bearing on the effect of this gravity drop.

Also the range at which your fire is to converge will have an important bearing on how much gravity drop will affect your fire. So whether or not you take gravity drop into account will once again depend on your squadron gunnery officer and with conditions peculiar to your squadron.

HANDY ANDY—THE MARK 18

You're going to run into the Mark 18 gun sight sooner or later since the Navy is using it widely on aircraft turrets. When you do run into it, if you are unable to take it apart and put it together again while blindfolded, don't feel too bad. Only experienced maintenance men are allowed to replace units, alter adjustments, or check for malfunctions.

You will want to know what this sight does, however, and how to boresight your guns when you're using a Mark 18.

The Mark 18 is an electrically-operated, computing, reflector-type gun sight. The gunner makes the proper settings on the control units, and then it is only necessary for him to "range and track" the enemy airplane or ground target. The sight automatically figures the proper point of aim. It makes no difference whether or not the enemy aircraft is in a pursuit curve or whether the target is stationary. The sight handles combat situations with ease, and the whole mechanism is a wizard when it comes to computing deflections.

You can see the Mark 18 gun sight assembly in figure 133.

The Mark 18 is really TWO sights in one. It has two optical systems and two reticles. When you look at these reticles through the reflector plate, they appear to be projected out into space. The reticel on the left which you see with your left eye is the FIXED RETICLE. The reticle on the right side of the reflector plate which you see with your right eye consists of a center

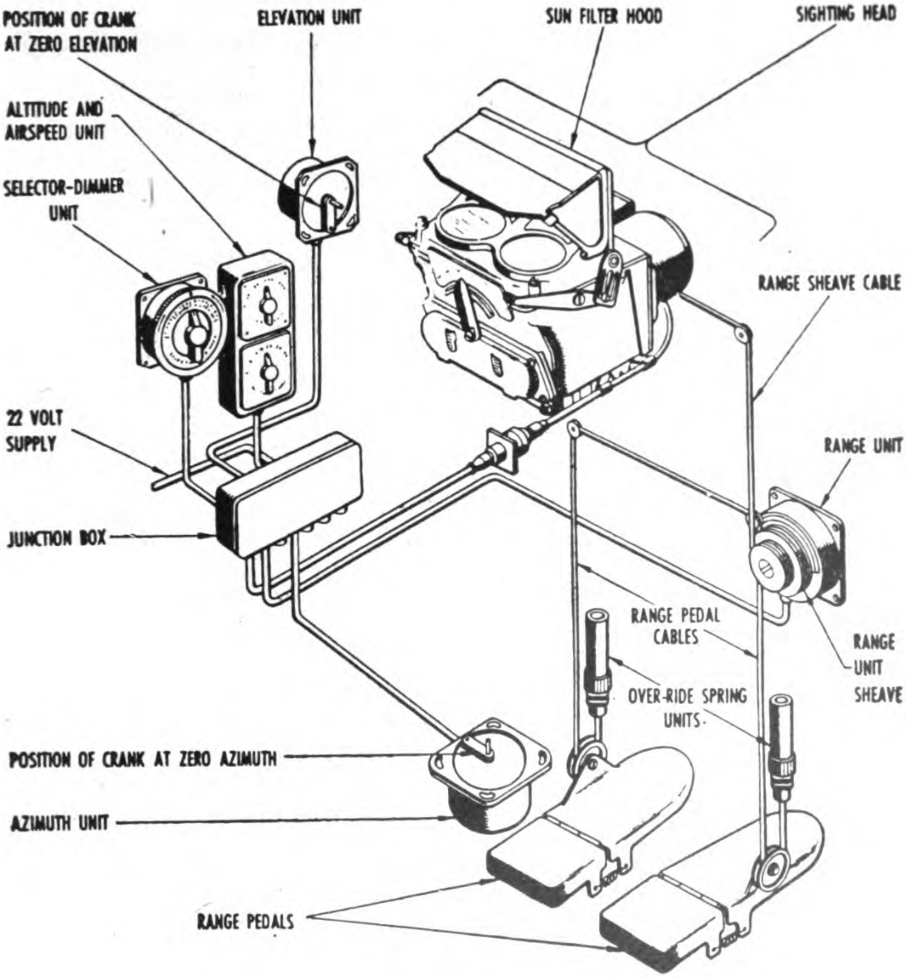

Figure 133—Mark 18 gun sight.

"pipper" which is surrounded by the six diamond-shaped pips arranged in the form of a circle. This is the GYRO RETICLE or MOVABLE RETICLE.

The circle formed by the six diamond-shaped pips of the gyro or movable reticle can be made to spread out and close in. When the turret is operated, the gyro reticle — the center pipper and six diamonds — moves around the reflector plate. If you use the Mark 18 sight properly, the gyro reticle automatically computes the correct deflection and gets hits for you. All you have to do is keep the enemy framed or "spanned" in an imaginary circle drawn so that it cuts the inside points of the six diamond pips of the gyro reticle. The center pipper forms the center of the imaginary circle.

The center of the fixed reticle is a cross, and indicates the direction that your guns are pointing. It is used for alining the two reticle systems, for boresighting, for maintenance checks — also gunner's checks — and as a standby sight in case of malfunction or failure of the gyro reticle.

BORESIGHTING THE MARK 18

Boresighting the Mark 18 gun sight establishes a parallel relationship between the center of the fixed cross of the fixed reticle and the bore axes of the guns.

BEFORE boresighting this sight, THE FIXED AND GYRO RETICLES MUST BE ALINED. They are alined when the center pipper of the gyro reticle is superimposed at an infinite distance with no windage, gravity, or relative speed allowances in the system.

After you have alined the fixed and gyro reticles, level the airplane athwartships and longitudinally. Turn the turret so that the guns are at a right angle to the center line of the airplane.

Using a spirit level, next adjust the nuts on the rear mounting post so that the guns are level, making sure the level is alined with the CENTER LINE of the gun barrel. Secure the nuts on the rear mounting post, and swing the turret to any convenient position. Now adjust the guns so that both bore axes bear upon an object at least 1,000 feet away. Do not disturb the elevation setting, as the guns need only be adjusted horizontally.

The next and last step is to adjust the sighting head so that the center of the fixed cross in the fixed reticle bears upon the same object as the gun bore axis. Remember, it is NOT NECESSARY to allow for gravity drop of the bullet. The sight automatically compensates for this.

How Well Do You Know—

AIRCRAFT TURRETS

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QUIZ

CHAPTER 1

WHY TURRETS?

1. What are the advantages of turrets on airplanes?
2. What two types of power are the motivating forces on aircraft turrets?
3. Name the three shapes of turrets used by the Navy, and describe each.
4. Identify the number of guns and their caliber, the shape, and type of power used on these turrets:
   (*a*) Grumman 150 SE–2.
   (*b*) Martin 250 CH–2.
   (*c*) Erco 250 TH–2.

CHAPTER 2

ELECTRIC TURRET SYSTEMS

1. In a schematic diagram, how are electrical parts indicated?
2. What electrical device in a turret can you call a "voltage divider"?
3. In an electrical circuit, the voltage at any particular point must be considered WITH RESPECT to what?
4. How would you describe the amplidyne?
5. What flux does the amplidyne utilize which is not desirable in the conventional generator?
6. What are the advantages of the cross-axis excited generator?
7. Is the series d.c. motor suitable for turret application? Explain.
8. What important part does the feedback voltage play in turret operation?
9. At full deflection of the train potentiometer pointer in normal speed operation, how many seconds should it take the turret to rotate one complete revolution?
10. How do you adjust the speed of a turret?
11. How can you decrease the current flow in the series field?
12. If a turret is over-compounded, how could you correct this condition?
13. (*a*) The anti-hunt field has one definite purpose. What is it?
    (*b*) In order to accomplish this, what must it do?

CHAPTER 3

GRUMMAN 150 SE–2 TURRET

1. In what aircraft is the Grumman 150 SE–2 turret installed?
2. Besides controlling the movement of the turret, what other important function does the control handle perform?
3. How many amplidynes and potentiometers are included in the Grumman turret's electrical system?
4. By what means is the automatic return of the turret to stowing position accomplished?
5. What is the purpose of the contour follower?
6. How is the fire interrupter switch operated?
7. What is the brake solenoid?
8. Describe the operation of the 9-ohm resistor circuit.
9. What is the first step in the trouble shooting procedure?
10. What instrument would you use most often to help you diagnose turret troubles?

CHAPTER 4

MARTIN 250 CE–16 AND CE–17 TURRETS

1. How is electric power transmitted to this turret?
2. (*a*) At normal speed, the turret will make one revolution in about how many seconds?
   (*b*) At high speed?
3. How is the action switch closed?
4. (*a*) What is necessary before the left-hand firing trigger will fire the left-hand gun and the right-hand trigger the right-hand gun?
   (*b*) How do you fire both guns?
5. What is the purpose of the torque tube?
6. What is the twofold purpose of the vibrator-inverter?
7. When the direct current from the potentiometer and the alternating current from the vibrator-inverter combine, what type of current results?
8. Explain what happens when the cam engraved on the cylinder of the profile interrupter strikes the micro-switch.

CHAPTER 5

HYDRAULIC TURRET SYSTEMS

1. How would you state Pascal's principle?
2. What do the letters P.S.I. mean when used in connection with pressure?
3. In hydraulics, what does the term (*a*) pressure refer to? (*b*) Force?
4. Can you compress hydraulic liquids by as much as 25 percent of their volume?
5. What type of hydraulic pump is used on most turrets?
6. Is the 2-way, 3-way, 4-way, or 5-way selector valve most common in aircraft hydraulic systems?
7. Is hydraulic power alone used to operate a turret mechanism?
8. Can you use a fluid with a mineral oil base interchangeably with a vegetable oil base fluid? Why?
9. Aside from the label on the can, how can you tell vegetable base oil from mineral base oil?
10. What kind of power actuating unit must be used to obtain rotary motion in the hydraulic turret?
11. What other type of power actuating unit is often used to elevate and depress the guns?
12. What is the function of the accumulator?
13. What type of selector valve controls the action of most hydraulic units?
14. What are relief valves?
15. Why is the filter an important unit in the hydraulic system?

CHAPTER 6

MARTIN 250 SH–2 TURRET

1. On what airplane is the Martin 250 SH–2 turret mounted and in what position?
2. What two main parts comprise this turret?
3. (*a*) How is the vertical rotation of the turret supported? (*b*) The horizontal movement?
4. What provides the power for turning the pump motor assembly?
5. How is the Clarke control valve adjusted?
6. What type of elevating unit does the Martin 250 SH–2 employ?
7. What is the function of the hydraulic swivel joint?
8. What drives the turret in train?

9. If the azimuth motor is turning in the wrong direction, what is the probable cause?
10. If the control valve is not closing in the OFF position, what is likely to be the effect on the azimuth motor?
11. (*a*) For what purpose is the hydraulic hand pump provided?
    (*b*) Why is it called a "double acting" pump?
12. From where is pressure obtained for the operation of the hydraulic gun chargers?
13. What is meant by the term "bleeding"?

CHAPTER 7

MARTIN 250 CH–3 TURRET

1. What is the main difference between the Martin 250 SH–2 and the Martin 250 CH–3?
2. Where is the Martin 250 CH–3 installed?
3. What is the activating unit in the structural interrupter?
4. What causes the structural interrupter valve to keep the guns from striking the fuselage?
5. What are the three sets of engravings on the profile interrupter cam cylinder?

CHAPTER 8

MPC 250 CH–5 AND CH–6 TURRETS

1. Where do you usually find these MPC turrets installed?
2. What is the difference between these two turrets?
3. What is the big difference in the MPC power system as opposed to the power system in the Martin turrets?
4. What type of hydraulic pump do you find in the MPC turret?
5. Where is the accumulator located in the MPC turret?
6. At approximately what pressure does the pressure regulator block off the fluid flow from the accumulator?
7. What type of driving mechanism operates the turret in azimuth?
8. By what means are the guns elevated in the MPC turrets?

CHAPTER 9

ERCO 250 TH–1 AND TH–2 TURRETS

1. In what aircraft are the Erco 250 TH–1 and TH–2 turrets installed?
2. What are the main hydraulic units in the Erco system?
3. Where is the accumulator located in the Erco system?
4. Does the Erco employ hydraulic gun chargers?

CHAPTER 11

BORESIGHTING TURRET GUNS

1. How would you define boresighting?
2. In boresighting on land, what is the minimum distance the sighting target should be from the aircraft?
3. Who will be the man that will very likely decide just what boresighting procedure you should use?
4. What are some factors which will determine the range at which your line of fire should converge?
5. If you are boresighting aboard a carrier, what kind of sighting target will you use?
6. How much attention should you pay to gravity drop in boresighting?
7. Why is the Mark 18 gun sight considered "two sights in one"?
8. In boresighting with the Mark 18 gun sight, how do you aline the two reticles?

ANSWERS TO QUIZ

CHAPTER 1

WHY TURRETS?

1. They increase the gunner's angle of fire and furnish power control movement of the turret and guns against the pressure of the slipstream.
2. Hydraulic and electrical power.
3. (*a*) Ball or spherical turret, in which the gunner, guns, and sight rotate about a common axis in elevation and a common axis in azimuth.
   (*b*) The cylindrical turret, in which the gunner, guns, and sight rotate about a common axis in azimuth only.
   (*c*) Teardrop turret, which has a streamlined shape with one axis of rotation along the chord of the streamlined shape.
4. (*a*) One .50 caliber machine gun, spherical in shape, electrically powered.
   (*b*) Two .50 caliber machine guns, cylindrical in shape, hydraulically powered.
   (*c*) Two .50 caliber machine guns, teardrop in shape, hydraulically powered.

CHAPTER 2

ELECTRIC TURRET SYSTEMS

1. By symbols.
2. The potentiometer.
3. To the voltage of some other point in the circuit.
4. The motor generator used with aircraft turrets.
5. The armature-reactance flux.
6. Exceptionally small field currents are required to produce the full output voltage, and the voltage builds up to its final value very quickly.
7. No. If it were used, the turret would run in only one direction.
8. It makes the turret more sensitive to control.
9. Eighteen seconds.
10. (*a*) To decrease the speed of the turret, increase the FBVR in series with the control field, and (*b*) to increase the speed of the turret, decrease the FBVR in series with the control field.
11. Bypass more of it around the field through the rheostat.

12. To correct the over-compounded turret, decrease the resistance in parallel with the series field.
13. (*a*) To act more or less as a shock absorber for any change in generated voltage.
    (*b*) Oppose the building up of the control field and oppose the breaking down of the control field.

CHAPTER 3

GRUMMAN 150 SE–2 TURRET

1. The TBF or TBM (Avenger).
2. The firing of the gun.
3. Two of each—one pair for train and the other for elevation.
4. The train return to neutral switch and the depression return to neutral switch.
5. Prevent the gun from striking (and damaging) the fuselage.
6. It is actuated by cams on a rotating cylinder which press against fire interrupter switches when the gun points at some part of the airplane, shutting off fire instantly.
7. It keeps the turret from rotating because of gravity pull or wind. When the turret operates, the brake solenoid is energized and the brake shoe is pulled free.
8. Check your answer with page 82.
9. Open all switches.
10. Voltmeter.

CHAPTER 4

MARTIN 250 CE–16 AND CE–17 TURRETS

1. By the collector ring.
2. (*a*) Eighteen seconds.
   (*b*) Eight seconds.
3. By depressing the action trigger on the control grips.
4. (*a*) The selector switch should be turned to INDIVIDUAL GUNS.
   (*b*) Turn selector switch to BOTH GUNS and press either trigger.
5. To transmit power from the elevation drive motors to the segment gears which raise and lower the guns.
6. To lessen the original friction drag in starting and to eliminate the residual magnetism in the amplidynes.
7. A pulsating direct current.

8. When the micro-switch is struck, the flow of current through the control field of the amplidyne is reversed, and in turn, the direction of motion of the guns is reversed.

CHAPTER 5

HYDRAULIC TURRET SYSTEMS

1. An increase of pressure on any part of a confined liquid causes an equal pressure increase throughout the liquid.
2. Pounds of pressure per square inch.
3. (*a*) The term "pressure" always refers to the force applied to each square unit of area.
   (*b*) "Force" is used to designate the total load that is applied to the total area.
4. No. Hydraulic liquids are noncompressible.
5. Variable volume pump (Vickers).
6. Four-way valves.
7. No. An electric motor must drive the hydraulic pump.
8. No. Vegetable base fluids deteriorate synthetic packings and hose, and mineral base oil deteriorates natural rubber packings.
9. Vegetable base oil is blue. Mineral base oil is red.
10. Hydraulic motor.
11. A hydraulic cylinder.
12. The accumulator serves as a source of hydraulic power when the pump fails to function and for emergency operation of certain units if necessary.
13. Clarke control valve.
14. Safety valves to keep pressure from getting too high.
15. It helps to keep fluid clean. Dirt in the system is the major cause of turret failure.

CHAPTER 6

MARTIN 250 SH–2 TURRET

1. The bow position of any PB2Y–3–4 airplane.
2. The ball and the saddle. The ball is a sphere, flat on two opposite sides. These flat surfaces fit inside the hubs of the saddle, which is a cylindrical shell with two opposite hubs projecting above it.
3. (*a*) The ball rotates by two horizontal trunnion tubes which support it to the saddle.
   (*b*) The horizontal movement is supported by rotation of the saddle upon the track.

4. An electric motor.
5. By means of four valve cages — two for azimuth and two for elevation, located on the left side of the valve housing.
6. The Parker hydraulic elevating unit, which is the hydraulic cylinder.
7. It houses three hydraulic lines which pass fluid between the ball and the saddle.
8. An azimuth drive motor, which is very similar to the Vickers constant displacement pump.
9. Tubing between control valve and motor are mixed up.
10. The motor will idle or drift.
11. (*a*) It is provided in case of failure of electric power.
    (*b*) Because the pump discharges fluid during both strokes of the handle — up and down.
12. Pressure is obtained from the hydraulic system and the accumulator.
13. Bleeding is the forcing of all air out of the hydraulic system.

CHAPTER 7

MARTIN 250 CH–3 TURRET

1. The main difference is in shape. Operation is very similar.
2. In the upper deck position of the PB2Y.
3. Structural interrupter valve actuates an electric solenoid.
4. A cam assembly meshed with the turret drive system causes the valve to reverse the flow of hydraulic fluid to the elevation motor.
5. The one at the top carries the outline of aircraft parts to be protected from the fire of the left-hand gun. The central portion carries the outline of parts which would come within the line of fire of the right-hand gun. The lower part of the cam is devoted to the structural outline of the airplane and causes the operation of the structural interrupter valve.

CHAPTER 8

MPC 250 CH–5 AND CH–6 TURRETS

1. In the PB4Y–2. The CH–5 is in the nose, and the CH–6 is in the tail.
2. The only difference is in their location in the turret. Operation is the same.
3. There is a power panel located outside the turret on the bulkhead of the aircraft.

4. Vickers constant displacement pump, located on the power panel.
5. On the power panel, along with most of the other hydraulic units.
6. 1,100 psi.
7. A hydraulic cylinder is used for azimuth drive.
8. By two hydraulic jacks.

CHAPTER 9

ERCO 250 TH-1 AND TH-2 TURRETS

1. In the waist position of the PB4Y-2.
2. The Vickers variable displacement pump, the Clarke control valve, and hydraulic cylinders.
3. There is no accumulator in the Erco turret.
4. No. It is for this reason that no accumulator is necessary.

CHAPTER 11

BORESIGHTING TURRET GUNS

1. Boresighting establishes the necessary relationship between the line of fire and the line of sight.
2. About 1,000 yards.
3. The gunnery officer of your particular unit.
4. The type of mission your airplanes are engaged in, the enemy aircraft, and whether or not you are encountering ground opposition.
5. A template or pattern.
6. This depends on your gunnery officer, but probably this factor will not be important.
7. Because it has both a fixed and movable (gyro) reticle.
8. The sight must be alined so that the center pipper of the gyro reticle and the center of the fixed cross of the fixed reticle are superimposed on each other.

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