CDX displacement convertor alignment and adjustment

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NATIONAL RESEARCH COUNCIL OF CANADA

RADIO BRANCH

CDX DISPLACEMENT CONVERTOR

(ALIGNMENT AND ADJUSTMENT)

OTTAWA

JULY, 1944

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(A discussion of its alignment and adjustment)

C O N T E N T S

NATIONAL RESEARCH COUNCIL OF CANADA

RADIO BRANCH

S E C R E T PRA-121

CDX DISPLACEMENT CONVERTOR

(A Discussion of its Alignment and Adjustment)

I. INTRODUCTION

This discussion of the CDX displacement convertor is based on the experience gained in designing, constructing, aligning and trouble shooting the original N.R.C. prototype of this convertor.

In designing the convertor, machining tolerances had to be based on the error they might introduce into the convertor. In only one or two cases has this caused the manufacturer any difficulty. For instance, the tolerances specified on the rack of not more than .002" out in a 10" length has caused some manufacturing trouble, but all other tolerances, gear meshes, etc. have been met without any trouble. In the case of the N.R.C. prototype, the convertor was first assembled, then aligned and checked and the various backlashes through gear trains measured.

The rack on the prototype was found to be out more than the specification allowed, but the prototype convertor just passes the test specifications.

It is hoped that this discussion will be of some aid in keeping the convertors in service in good running order and should any trouble develop, speed up the process of trouble shooting.

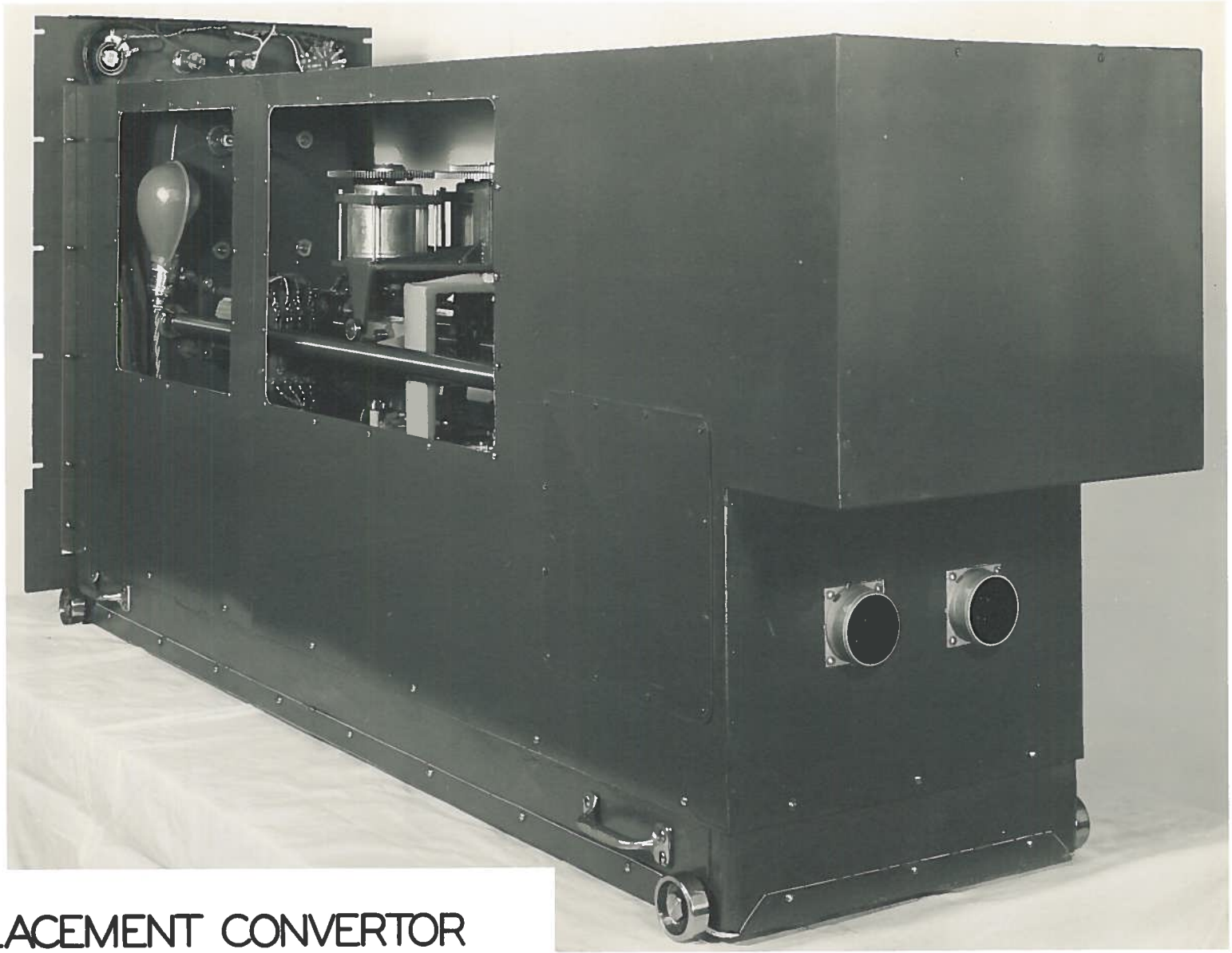
II. GENERAL DESCRIPTION

The CDX displacement convertor was designed as an integral part of the CDX 10-cm. coastal defence radar set. It not only functions as a displacement convertor, giving out gun range and bearing for various gun displacements from the CDX antenna when fed with the CDX range and bearing, but also includes the range goniometer and condenser, which are fundamentally part of the radar ranging system.

The whole unit is enclosed in a sheet metal cover and is mounted in the right hand side of the range rack at a convenient height for the operator. A general view of the convertor is shown in photos REX-815-P and 816-P.

The displacement convertor is fundamentally an accurate reproduction to scale of the relative positions of the gun, the CDX and the target. Its purpose is to convert continuously the CDX readings of range and bearing to those correct for the gun, for any displacement between gun and radar set up to 1,000 yards. Under certain limitations of radar bearing with respect to gun location or by limiting minimum gun range to more than the present 5,000 yards, this displacement can be exceeded.

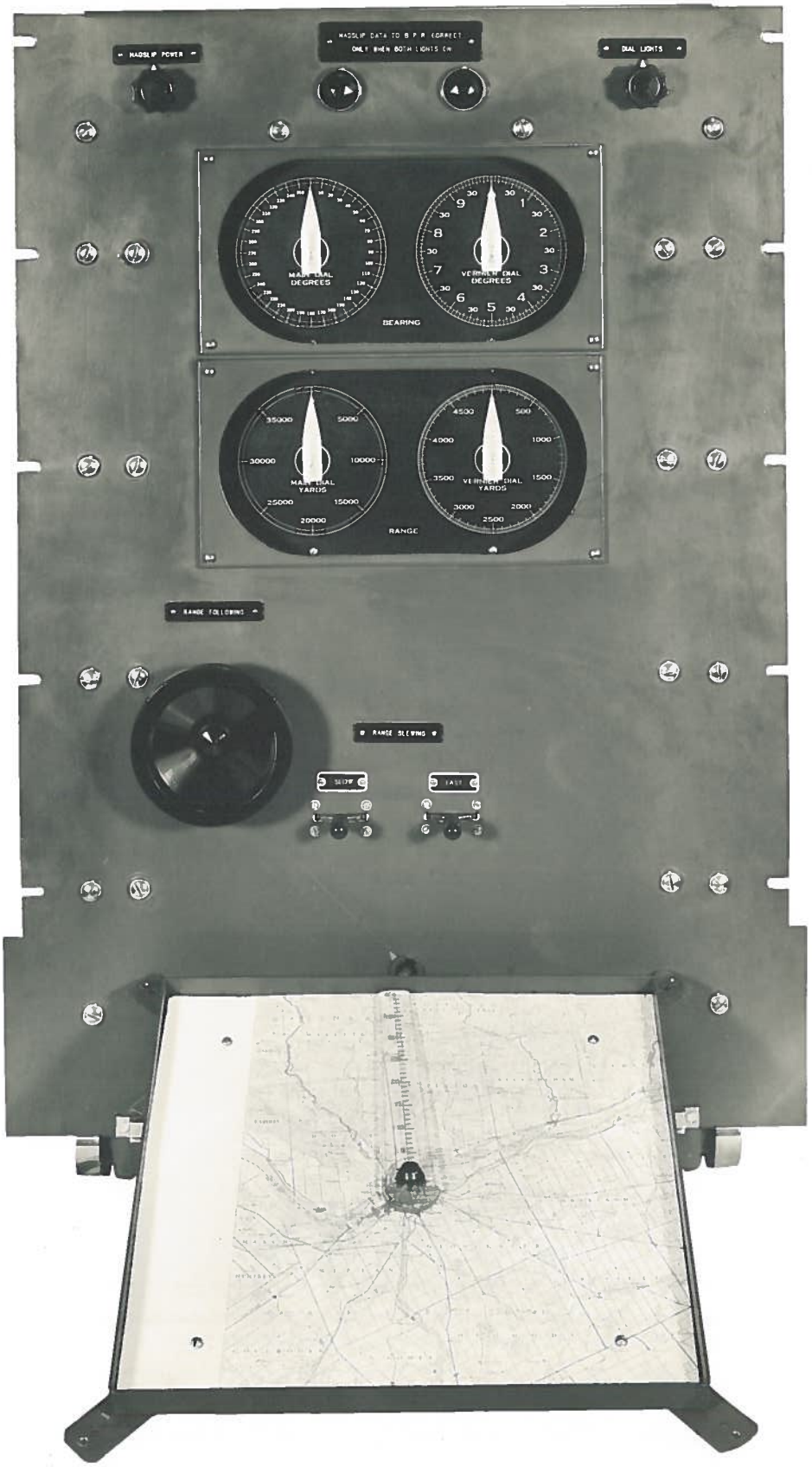
A simplified line diagram of the CDX convertor is shown in Figure 1.



DISPLACEMENT CONVERTOR

RIGHT SIDE, REAR VIEW_ DUST COVER IN PLACE

REX-816-P



DISPLACEMENT CONVERTOR

FRONT PANEL AND BEARING
PRESENTATION UNIT

REX-815-P

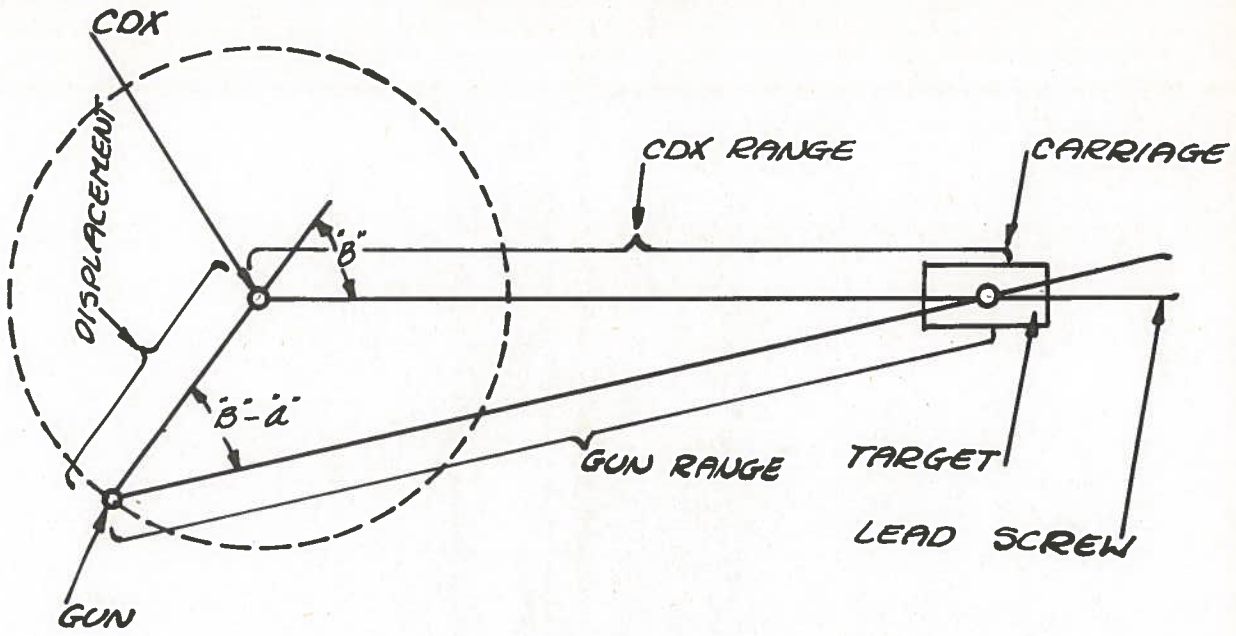


Fig. 1

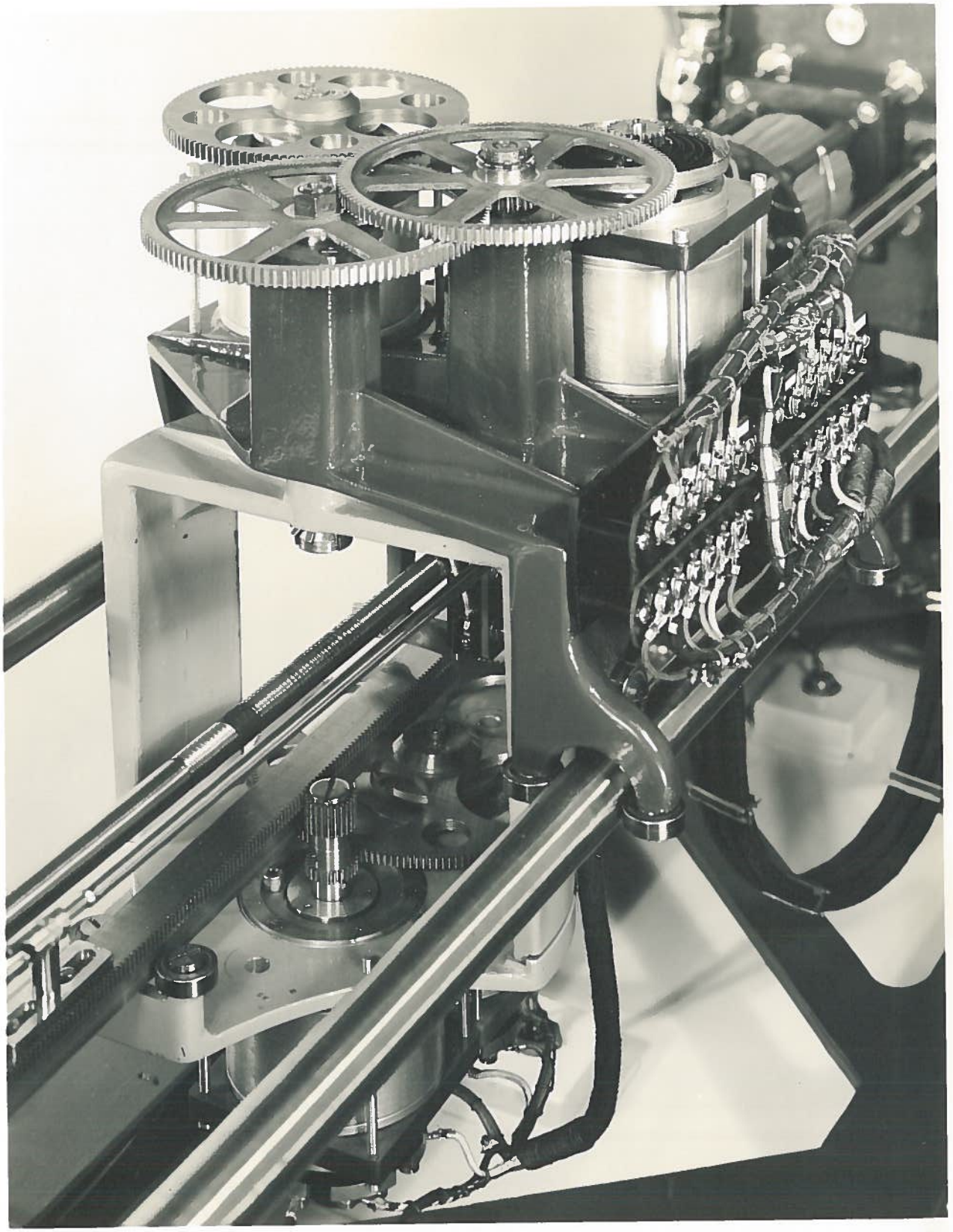
If the above diagram were looked upon as a map, the CDX, GUN and TARGET are shown in their relative positions to a scale of 2083 yards = 1 inch. However, if the target is moving about the CDX, the target does not swing about a fixed CDX-GUN base line as normally would be expected, but, instead, the GUN-CDX base line pivots about the CDX position and the target moves up and down a fixed line, its distance from the CDX representing the CDX range to scale.

By swinging the gun about the CDX and limiting the displacement to 1000 yards for 5000 yards minimum range, the angle through which the gun range rack can swing is limited to approximately 12° and thus the physical size of the convertor is held to reasonable limits and the vernier gun bearing hunter motion is limited to plus or minus one revolution. The scale of 2083 yards/inch was arrived at as the largest scale feasible without making the convertor overshadow the set in physical size. With this scale, the overall accuracy of 10 yards is possible without resorting to anything out of the ordinary in machining tolerances.

Referring to Fig. 1, if the target has a bearing from CDX-GUN baseline "b" and the carriage is at a certain CDX range with the correct displacement set in on the displacement crank, then it is apparent that the length of the gun range rack represents the gun range to scale and the bearing of the target from the gun position is the angle "b-a".

The gun range rack of the convertor drives the gun range magslip transmitters, photograph REX-823-P, mounted on the range carriage.

The gun bearing angle "b-a" is arrived at as follows:-
Magslip data of the CDX Antenna bearing angle "b" is fed into the "LOCAL" windings of a pair of Magslip Hunters, geared 36:1 and mounted on top of the range carriage. The rotors of these Hunters are swung through the differential angle "a" by movement of the rack. Thus, Magslip receivers connected to the



RANGE CARRIAGE

REAR

REX-823-P

"DISTANT" windings of these Hunters will read the angle "b-a" due to the action of the Hunters, and this angle is the required bearing of the target from the gun. Great bearing accuracy, especially at long ranges, is possible with this system, as the CDX bearing, which is accurate to within one or two minutes, has a small correction added to it, rather than a whole new "gun bearing" angle having to be measured with great accuracy.

Photograph REX-820-P shows a general view of the convertor from the rear.

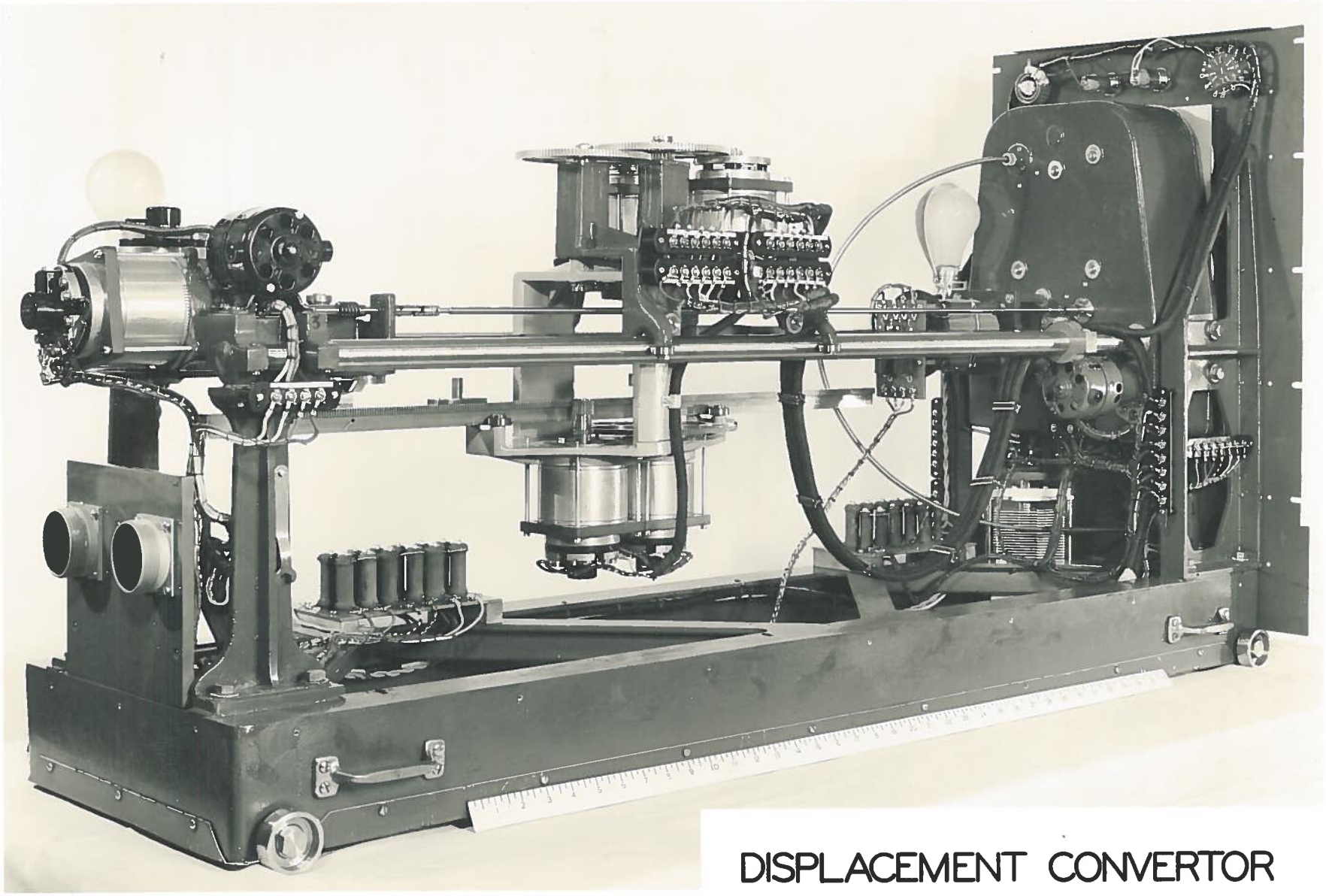
The entire convertor is mounted on a cast aluminum base, which can be rolled in and out of the rack on small wheels. At the left hand end of this casting is mounted the bearing displacement drive casting. Mounted on this casting are two magslip transmitters geared 36 to 1 and 1 to 1 with respect to the displacement crank.

A small "Universal" type of motor, is mounted on this casting and drives the two follow-up Magslips and the displacement crank until their rotors line up with the CDX Antenna bearing magslip transmitters.

The stator windings of the Antenna Magslip transmitters are connected through protective resistors to the stator windings of the follow-up magslips and thus a magnetic field is set up in the stators of the follow-up magslips in line with the rotors of the antenna transmitters. The rotors of the follow-up magslips are connected through the follow-up amplifier to the armature of the follow-up motor.

The field supply of the follow-up motor is the 55 volt magslip supply. Thus the follow-up motor drives the follow-up magslips and displacement crank until it lines the follow-up magslip rotors at 90° to the magnetic field set up by the antenna magslips, when there is a voltage null and the follow-up motor stops. As soon as the antenna rotates, a voltage appears across the follow-up motor armature which drives the follow-up magslips to a new null position. The phase relation through the servo chassis is so chosen that the motor always seeks the null position, regardless of which side of the null it happens to be on. By means of a bias applied to the Vernier magslip amplifier channel whenever the main follow-up is more than 1-1/2 degrees from the null position, only the main magslip transmitter controls the motor and thus the main magslip transmitter will feed the follow-up magslip and displacement crank to within 1-1/2 degrees of the correct position, at which time the Vernier magslip transmitter will take over and put the displacement crank to within a few minutes of the correct position.

Should the follow-up magslips be 180° away from the antenna magslips when the power is applied, the Vernier channel would control the follow-up as the main magslip would indicate a null, and the correction would follow 180° out of step.



DISPLACEMENT CONVERTOR

LEFT REARVIEW

REX-820-P

To check this, a push button "Convertor Orient" is pushed while the antenna is moving. This switch prevents the Vernier channel from operating and as soon as the antenna has rotated one degree or so, the convertor will realign itself on the correct null and the push button can be released.

Thus, as the operators follow a target with the radar set, the displacement crank of the convertor is continuously and automatically turned to the correct angle "b" to solve the problem.

A small shaft also feeds this information to the front panel of the convertor, where the operator can observe if the follow-up is functioning correctly by comparing the reading on the front panel with a magslip receiver test box connected to the antenna bearing magslip transmitters. A map is also located in the table top in front of the range operator and this follow-up also drives a pointer on this map, indicating to the operator the approximate location of the target on the map. This would be of value in warning friendly vessels of shoals or other danger areas.

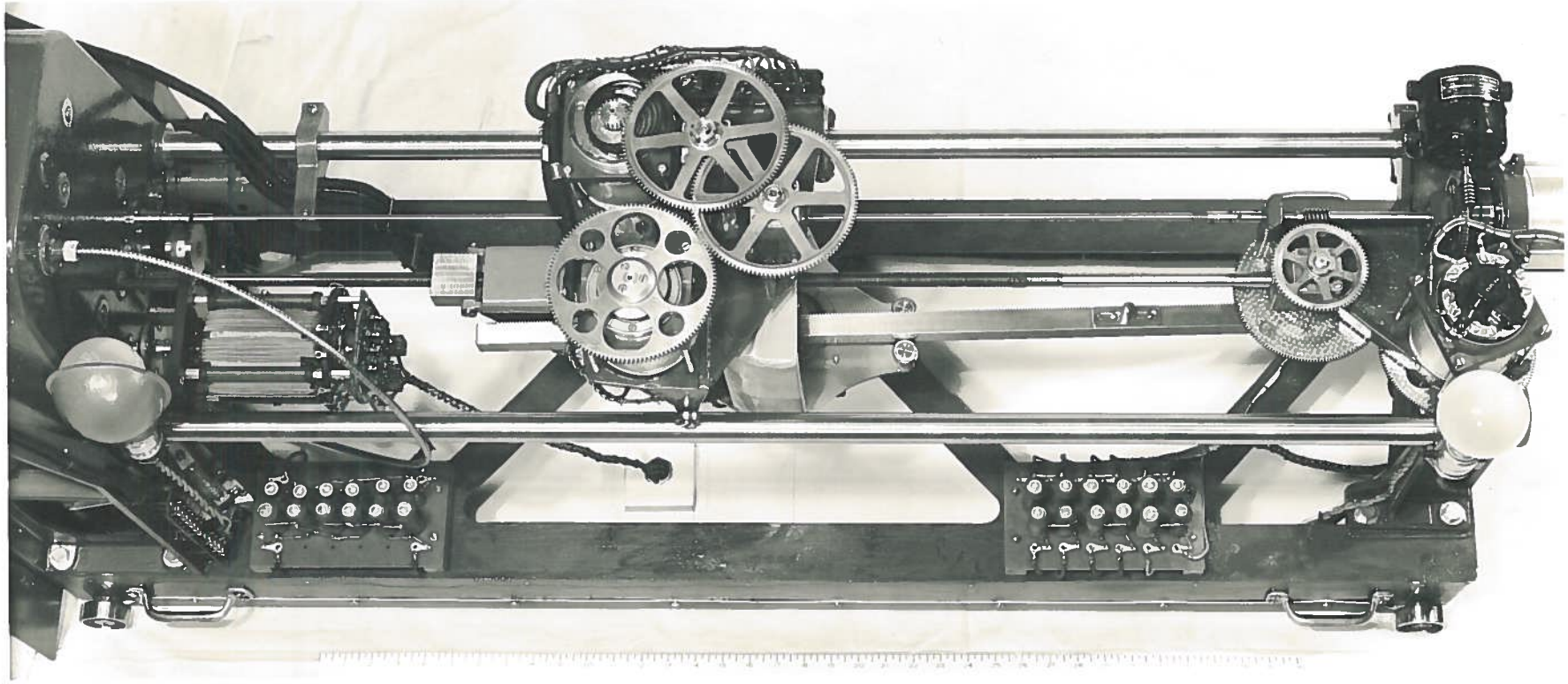
Referring again to Photo 820-P, two lengths of heavy drill rod can be seen joining the follow-up casting on the left hand end of the base with the Range gearbox unit at the right hand end of the casting. Driven along these drill rod tracks on ball bearing rollers by a lead screw is the Range Carriage. This lead screw can be seen in Photo 818-P located midway between the two lengths of large diameter drill rod.

The upper portion of the range carriage, painted a darker color in the photograph, is restrained by its ball bearing rollers so as to run along the drill rod tracks without any sideways or turning motion.

Pivoted from this carriage is a yoke casting through which the rack passes. By means of ball bearing guides running on the sides of the rack, this yoke casting always turns with the rack. The pivot point of this yoke represents the target.

The vernier gun range magslip transmitter is mounted in this yoke casting, also with its center located on the pivot point, so that the length of rack to this point is a measure of the gun range. The gun range rack is so located that it meshes with a gear mounted on this magslip. A main gun range magslip transmitter is geared to this vernier transmitter. The ratio of this gearing provides gun range data at 5000 yards and 40,000 yards per turn.

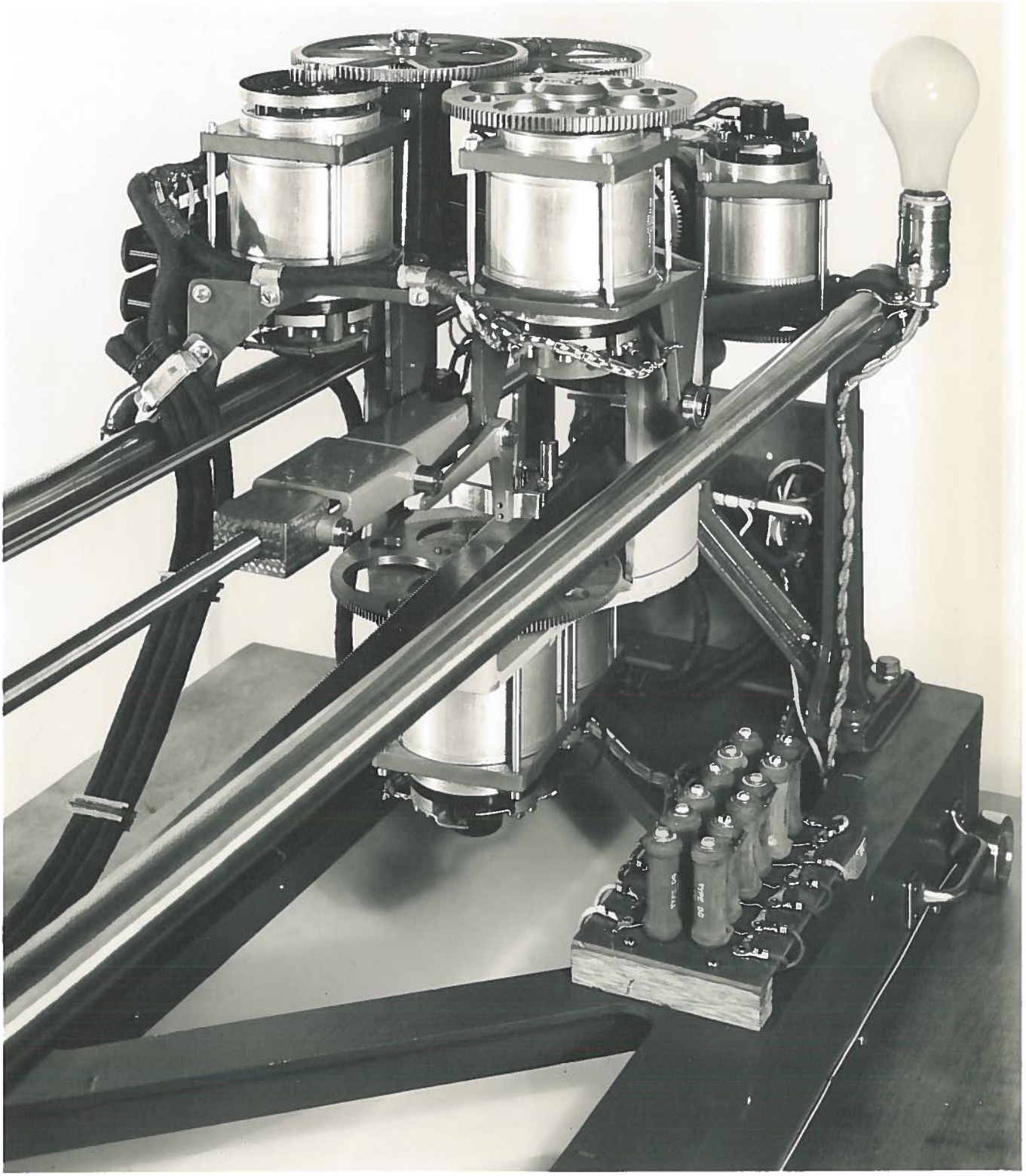
Referring again to Photo 818-P, the pivoting motion of the rack turns the yoke casting which in turn drives the vernier and main magslip bearing hunters, which are mounted on top of the carriage. The gear train driving these hunters can be seen on top of the carriage. The main hunter is geared 1 to 1 with the pivot



DISPLACEMENT CONVERTOR

TOP VIEW

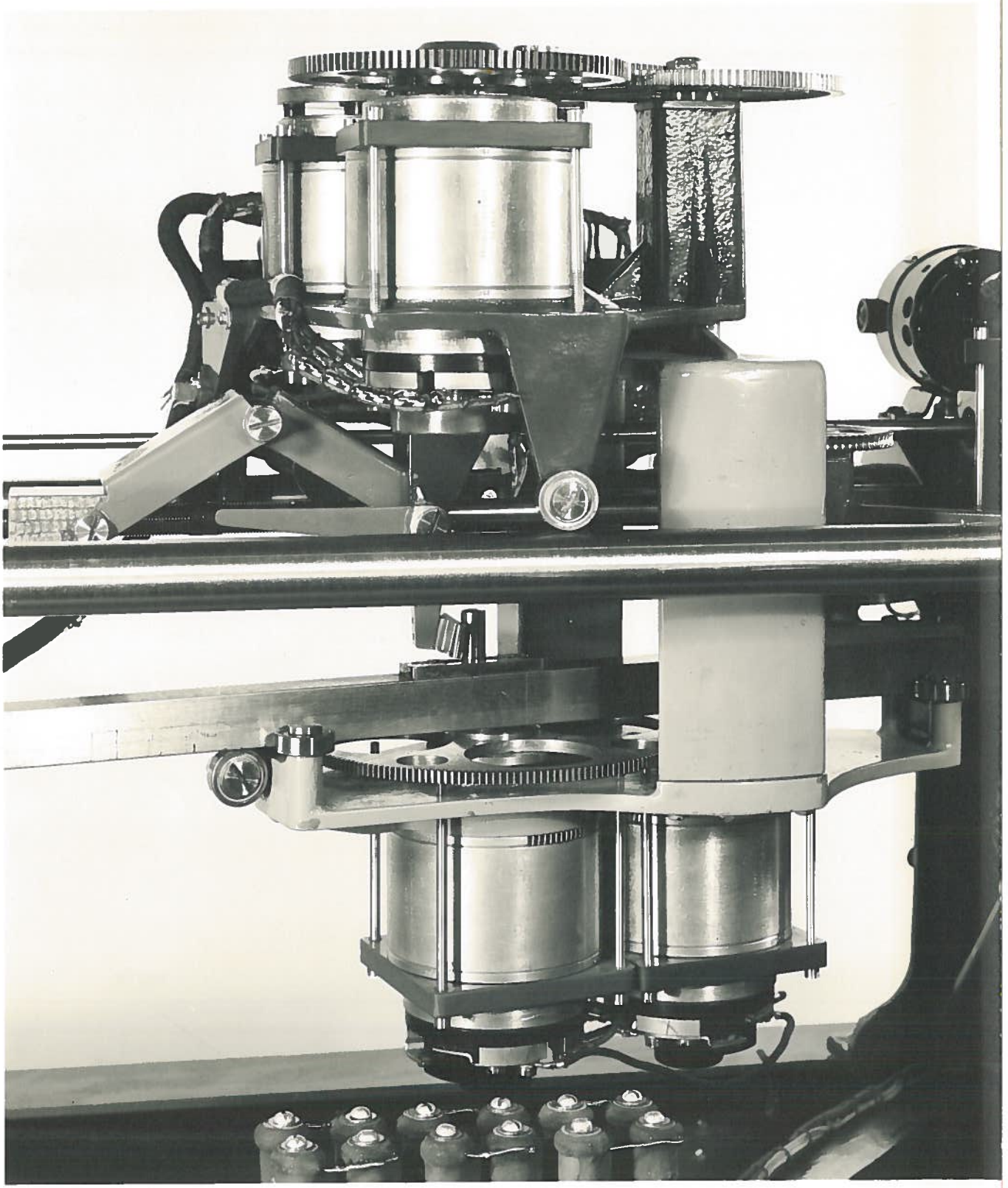
REX-818-P



RANGE CARRIAGE

FRONT

REX-824-P



RANGE CARRIAGE

RIGHT SIDE - TOGGLE TRIPPED

REX-822-P

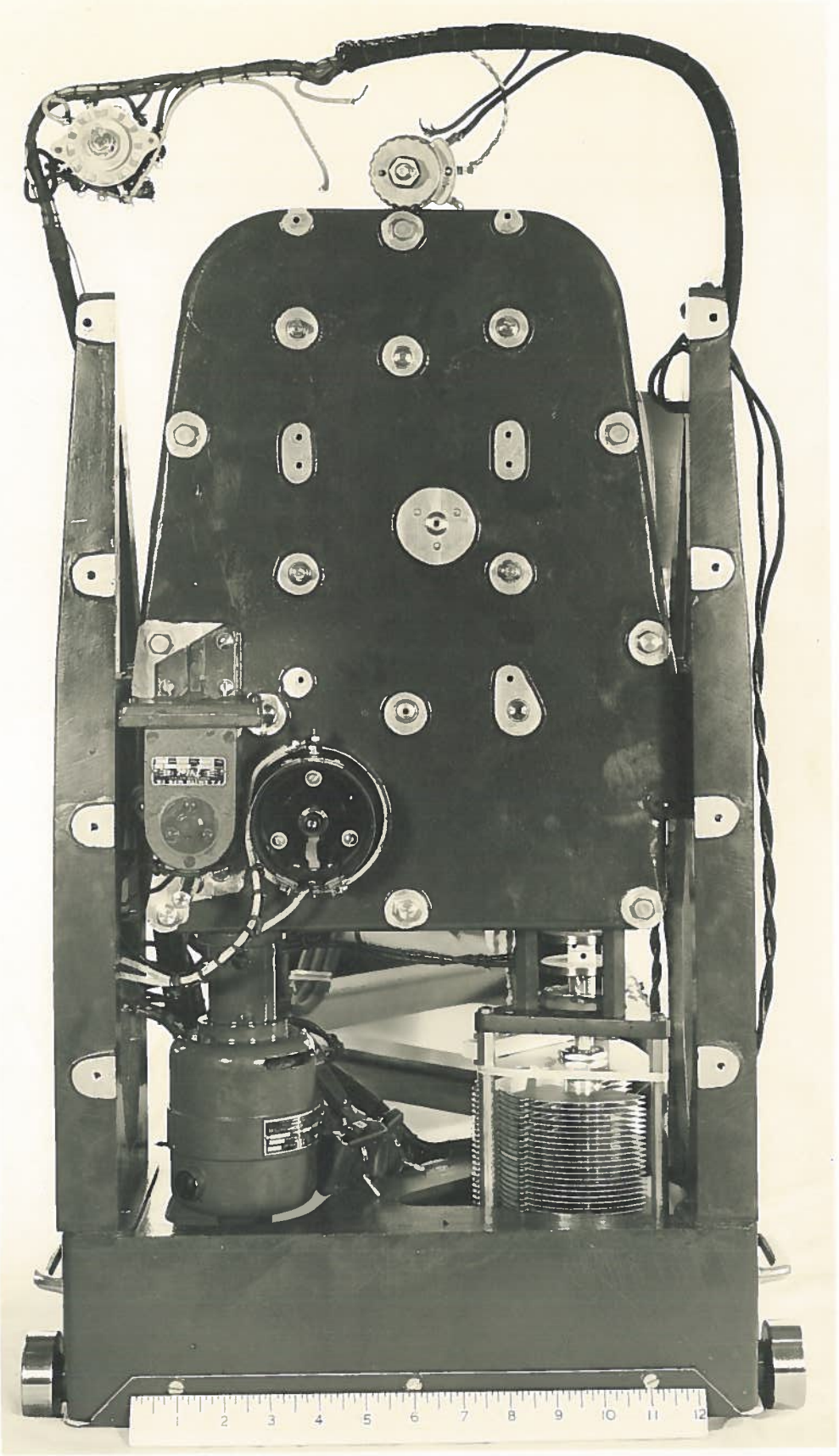
shaft, while the vernier is geared up 36 to 1. This gear train has to be held to very close tolerances, and in the photograph can be seen the first attempt at spring loading this train by means of a clock spring. This was not satisfactory, as the spring load was increased 36 times by the gear train and tended to always spring the rack towards one side which introduced considerable error into the bearing readings at short ranges. An improved split gear type of spring loading was substituted, which has proved satisfactory.

On production models, the idler gear of this train will be adjustable so as to minimise backlash through this train.

In photo 824-P, the follower block which runs on the lead screw, can be seen. This block transmits the drive from the lead screw, through a toggle to the range carriage. Due to the limitation of 12° rack travel, the carriage cannot travel to less than 5,000 yards range with 1,000 yards displacement when the displacement crank is at right angles to the lead screw. As it is necessary for radar checking purposes to be able to run the radar range below zero, some means must be provided to prevent movement of the carriage below 5,000 yards range while allowing the follower block to keep on travelling to zero range. This is accomplished by locating a pin on the rack (Photo 822-P) which strikes a curved arm pivoting on a bracket fastened below the carriage. The other end of this arm strikes the center pin of a toggle joint which connects the follower block to the range carriage. Once the center pin of the toggle is lifted approximately one quarter inch above the other two pins, further movement of the block tends to fold the toggle rather than move the carriage and hence the block can travel further down the lead screw leaving the carriage stationary. The instant the toggle breaks, a microswitch is opened which sets all outgoing magslip information to datum zero, preventing incorrect information from being transmitted from the convertor. The operation of this switch also extinguishes a light on the front panel.

The range gearbox is located at the right hand end of the drill rod tracks in Photo 820-P. This gear box enables the operator to control the speed of the range goniometer and condenser and to read the resulting radar range on dials. The front panel of the convertor is shown in Photo 815 P. The upper pair of dials give the radar bearing through the bearing follow-up system, the dials reading 360° and 10° per revolution.

A flexible shaft is connected from the rear of the 10° pointer shaft to the bearing presentation map, which can be seen in front of the convertor. A pointer pivoted at the centre of the map has a graduated scale on it reading to



RANGE GEAR BOX

FRONT VIEW

REX-817-P

40,000 yards radar range. The operator reads the radar range of the target and then glances at that range on the pointer, which gives him the location of the target to within 500 yards on the map. This map could be divided into grids, which would enable the operator to give the grid square in which the target is located.

Immediately below the bearing dials are the radar range dials. These dials, reading 40,000 and 5,000 yards per revolution are geared directly to the goniometer, 1000 yards per turn, to the range condenser, 80,000 yards per turn and to the lead screw driving the range carriage of the convertor, approximately 208 yards/turn. By means of two differentials, the lead screw and hence the above mentioned dials, goniometer and condenser, may be driven simultaneously or separately by either a high speed slewing motor, which can be seen to the left under the range gearbox in photo 817-P. (The range condenser can be seen to the right of this motor) or by a low speed tracking motor controlled by the rheostat in Photo 817-P, which is driven by the handwheel. The handwheel also drives the lead screw directly, giving an aided laying ratio of 1 yard direct lay to 1 yard/sec. rate change. The tracking motor enables the operator to follow targets travelling directly towards or away from the radar set at speeds up to 60 m.p.h. and greater speeds for targets approaching obliquely. The tracking motor may be seen in Photo 820-P on the rear of the range gearbox, below the large drill rod tracks.

The goniometer can be seen to the left of this motor, behind the drill rod tracks and also in place in Photo 818-P, where it can be seen between the drill rod track and the lead screw on the rear of the range gearbox.

The rate of the range tracking motor is controlled electronically by a motor control system identical to that used on the GL IIIC range gearbox. The control handwheel drives a rheostat, which is so connected that it gives zero motor speed at its mid position, and increasing in speed when moved in either direction. Reversal of direction is accomplished by means of cams and microswitches operating on the rheostat shaft. These cams may be seen in Photo 818-P between the goniometer and tracking motor. A small "Pilot" alternator* which forms part of the speed control, is driven directly by the tracking motor. The control circuit operates in such a manner that the tracking motor rotates at a fixed speed within a few per cent for large variations of load for any given handwheel position. The maximum speed obtainable is approximately 5000 r.p.m. which gives the 60 m.p.h. range rate.

The range slewing motor drives the range convertor at 100,000 yards per minute for a motor speed of 5,000 r.p.m. This motor is controlled by two telephone switches mounted to the right of the handwheel. The right hand one gives

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* This small "Pilot" alternator can be seen in Photo 817-P above the range slewing motor.

high speed slewing at the above rate, the direction depending on whether the key is pushed to the left or to the right. The left hand switch gives a slow slewing rate which can be controlled by a rheostat mounted to the right of the slewing switches.

To prevent the follower block on the lead screw from being driven too far in either direction, cams, mounted on the range condenser shaft, shut the power off the tracking and slewing motors at approximately -1000 yards and +38,000 yards. The switches are so arranged that when the motor has been driven past the limit in one direction, operation of the switch in the opposite direction enables the operator to run the motor in the opposite direction. On production models an additional safeguard has been added by so threading the lead screw that if the limit switches failed for any reason, the following block would run off the end of the lead screw thread before damaging the convertor. This would entail re-calibrating the radar range dials after getting the follower block back on the lead screw.

The incoming and outgoing power and magslip information is taken out through the rear of the convertor, Amphenol plugs being used on the proto-type model and Jones plugs on production units.

The range condenser and range goniometer leads are brought out to sep-arate receptacles on the bottom of the convertor so as to get short leads.

If radar range and bearing information is required on magslips, the convertor can be placed on zero displacement, when the convertor will transmit radar range and bearing and also the toggle trip pin on the rack may be removed and the convertor carriage allowed to travel through zero range.

III. ALIGNMENT OF CONVERTOR IN SERVICE

As shipped by R.E.L., the displacement convertor is aligned with 0° baseline bearing and 1,000 yards displacement. A convertor as received from the factory will be considered first.

After uncrating, the convertor should be examined for damage in shipment, such as cracked base castings.

The dust cover should then be removed and a further careful examination made, all bolts and set screws being checked to see if they have loosened. The clamps or lashings used to hold the range carriage and rack in position during shipment should then be removed, and the convertor placed on a table so arranged that the cables from the rack can be plugged into the rear of the convertor. The goniometer and condenser leads will not be required for testing of the convertor.

The servo chassis and range motor control chassis and their associated power supplies will be required in the range rack, and should have power supplied to them. The Antenna Magslip transmitters should also be in position and wired through to the convertor.

The range tracking motor should then be tried. Rotation of the handwheel clockwise from the mid-position (as read on the range rate dial to the right of the handwheel) should cause the motor to gradually increase speed and increase the range readings on the dials. Counterclockwise rotation should produce a reduction of range.

The range slewing switches should then be tried. The right hand switch (to the right of the range handwheel) should give increasing range when pushed to the right and decreasing range when pushed to the left. The left hand slewing switch should give the same effect at a slower rate.

The radar range limit switches should be checked. Run the radar range out to the maximum, and the motor should stop running at approximately 37,000 yards. If it does not, the appropriate cam located above the range condenser below the range gearbox should be adjusted until it does. Great care should be taken to tighten both set screws on the cam, as failure of the limit switch to operate would allow the follower block to run off the lead screw, necessitating setting of the radar range dials over again.

The minimum range limit switch should also be checked and should operate between 500 and 1500 yards below zero range. The same instructions hold for this limit switch.

The magslip receiver test boxes should then be plugged into their appropriate receptacles on the rack. Then, with the magslip power switch

turned "off" (left hand switch in row of switches above bearing dials) the bearing and range magslip receivers should read datum zero. (120° and 20,000 yards as shipped by R.E.L.)

If the receivers do not read datum zero, they should be adjusted. If the receiver is only a small part of a revolution out, the clamp ring holding the magslip receiver in the test box should be loosened and the body of the receiver turned until the pointer reads zero. If the receiver is badly off zero, the front panel of the test box should be removed and the small screw in the centre of the pointer loosened. The pointer should then be removed, replaced in the zero position and tightened up again. Great care should be taken in performing this operation not to place any end pressure on the small shaft of the receiver, as the other end of the shaft rests on a very thin diaphragm which is easily damaged. After replacing the pointer, the receiver should be aligned exactly to datum zero by moving the body of the receiver as described above.

When the magslip power switch is turned "on", the magslip receivers should read the bearing of the Antenna. The switch on the bearing magslip receiver box should be in R.D.F. bearing position for this test. The coupling between the antenna and the antenna bearing magslip gearbox should be adjusted until the vernier receiver reads zero and then the main magslip transmitter body turned until its receiver reads the nearest even division, i.e., 110° or 120°, etc.

The antenna can then be sighted on a known landmark and the coupling adjusted until the receivers read the bearing of that landmark from the radar antenna.

The antenna then should be rotated until the receivers read exactly 120° 00', and the entire test procedure for the convertor run through as described under CDX Test Specification, (Appendix #1), except that it is not essential to line up the convertor servo mechanism. (See page 17).

This checks the entire convertor for accuracy at 1000 yards displacement.

The convertor dials should then be made to read exactly 25,000 yards radar range and 0° radar bearing and the bearing slide crank adjusted until the gun range magslip receivers read 25,000 yards plus displacement desired.

The bearing crank should then be swung around several times (using the bearing follow-up motor in the "check" position) and the gun range magslip receiver watched for the maximum variation. This should be equal to exactly twice the desired displacement. If not, the slide crank is readjusted until it is.

The radar bearing dials on the front should then be turned to 0° and the radar range set at approximately 25,000 yards. On throwing the switch on the magslip bearing receiver box from R.D.F. bearing to gun bearing, no change of reading should be observed. If there is a change, the bodies of the magslip hunters mounted on the range carriage should be adjusted slightly to eliminate this change.

The front bearing dial pointers should then be loosened on their shafts and turned to the bearing of the pivot gun from the radar set antenna.

The bearing follow-up motor control switch should then be placed on "operate" and the front radar bearing dials should then follow to the antenna bearing plus the amount the front pointers were moved through to get the base line bearing. The vernier channel of the servo chassis should then be switched off, the threshold control turned fully to the left and the main channel gain control turned on full. The convertor should then follow the antenna to within 10 or 15 minutes.

The main bearing follow-up magslip should then be adjusted by rotating the body until the front radar dials match the magslip bearing receiver dials with the switch on R.D.F. bearing.

The main channel of the servo should then be switched off and the same procedure repeated for the vernier channel, only the gain control should be set just below the point at which the follow-up motor tends to oscillate.

The convertor should then be set 2° off the antenna bearing (with the bearing follow-up motor switch on check) and the vernier channel shut off and the main on full.

The threshold control should then be advanced until the convertor starts to follow and then left in that position. A check should be made by placing the convertor 2° off in the other direction, and seeing if the motor is just on the point of operating. The vernier channel should then be switched on and the convertor will follow to within 2 or 3 minutes of the antenna bearing reading.

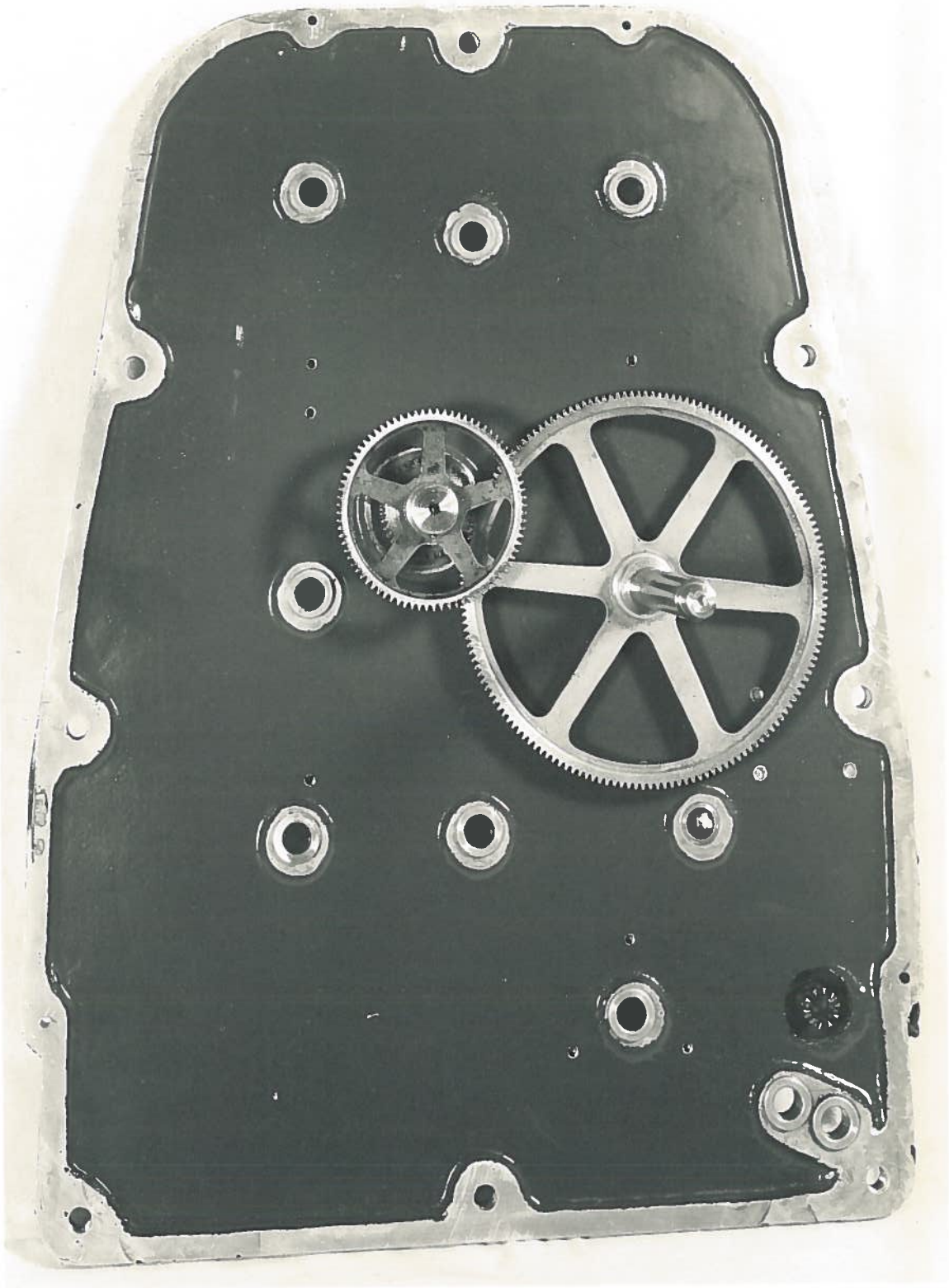
The toggle trip pin on the rack should then be placed in the correct position for the particular displacement being used.

The range at which the toggle trips should be checked. The gun range at which the gun range magslip receivers trip to zero should be approximately = 4.5 x displacement +500 yards. This range may vary about 200 yards depending on the position of the displacement crank. If it does not trip at this range, the pin should be relocated so that it does, as serious damage can be done by allowing the convertor to operate below the range given by the above formula.

The rack may be forced into the side of the dust cover and the yoke casting suspended from the range carriage may get bent.

The dust cover can now be placed on the convertor and the convertor placed in the rack.

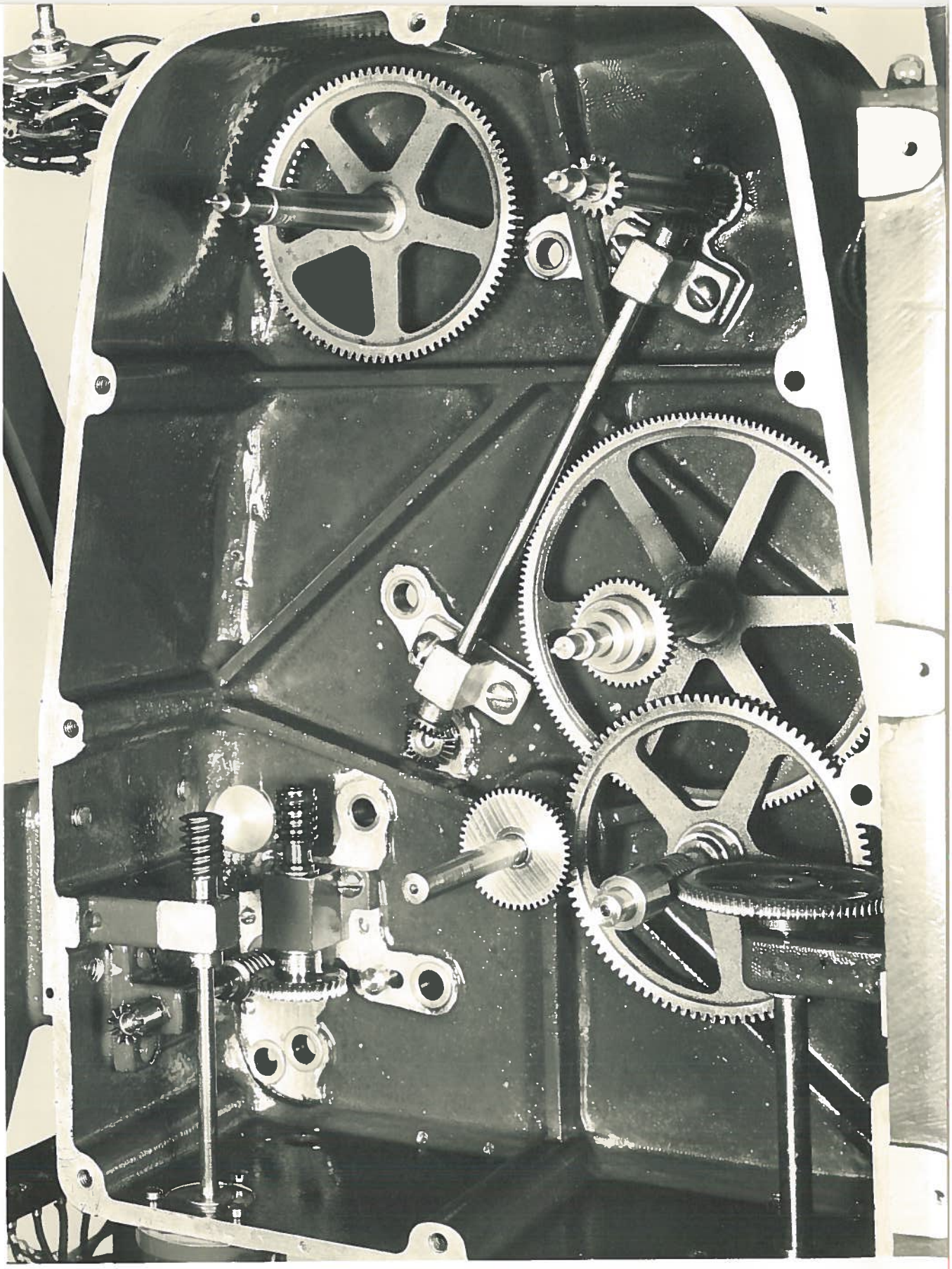
The presentation map should then be placed in the table top and the flexible shaft connected. The map pointer should be adjusted to read due north when the convertor dials read 0° and should follow the front dials. Care should be taken in connecting the flexible shaft that the square end of the flexible shaft enters the square hole in the map unit shaft. The other end of the flexible shaft should be in the shaft in the gearbox. This can be checked by attempting to turn the projecting end of the flexible shaft which should not turn. If it should turn, the shaft should be turned and pushed in until the square end engages with the square hole in the shaft in the gearbox.



RANGE GEAR BOX COVER

INNER SIDE

REX-828-P



RANGE GEAR BOX

INSIDE VIEW PARTIALLY ASSEMBLED

REX-830-P

IV. SERVICING AND TROUBLE SHOOTING CDX CONVERTOR

Once the CDX convertor has been installed in a given location and operates satisfactorily there is very little to get out of adjustment.

Approximately once every week of normal operation, the convertor should be rolled about a foot out of the rack and the three grease fittings on the range gearbox should be given a shot of Intava grease X62-43. This is all the attention required by the convertor between overhauls.

Every six months of regular service, the convertor requires a thorough overhaul. First, the regular test check of the convertor should be carried out and plotted. Then the complete convertor should be removed from the rack and the dust cover removed. The front panel should then be removed and after removing the range speed control potentiometer and alternator and removing the pointers, the front cover of the gearbox can be removed. The intermediate shaft and main dial of the range dial drive comes out with the cover. This can be seen in Photo 828-P. There are two locating pins in this cover to facilitate accurate alignment of the shafts. All the shafts and gears can then be removed and cleaned except the ones seen in Photo 830-P. However, the large gear and shaft at the very top of the photo can be removed. The remainder of the gears can be cleaned while in place in the gearbox. In order to remove the left hand differential it is necessary to remove a taper pin holding the dead shaft on which it turns. Then the shaft can be pulled out and the differential removed. All the gear teeth should be well coated with X62-43 grease before reassembly. All oilite bearings should receive a few drops of Intava Instrument Oil or its equivalent.

The range slewing and tracking motors and the bearing follow-up motor should be removed and disassembled.

The commutators should be cleaned, brushes inspected and the bearings lubricated with X62-43 grease. The motors can then be replaced. The range slewing and tracking motors are removed by removing three screws holding the motor into the extension tube and then driving out the taper pin holding the hard rubber coupling to the shaft. A hole is provided in the extension tube for this purpose.

After reassembling the range gearbox, the rack, lead screw, and all the gearing on the range carriage and displacement crank drive should be thoroughly cleaned with Iosol 1028 and then greased with X62-43 grease. All exposed steel surfaces, such as the drill rod tracks should be very lightly coated with a film

of X62-43 grease to prevent rust. All the ball bearings used in the convertor are of the shielded type, and should not require lubication due to the very light and intermittent duty. They should be examined however for freedom of turning and if any evidence of binding is found should be replaced.

The toggle joining the lead screw follower block to the range carriage should be removed and all bearings cleaned, re-oiled with Intava instrument oil and replaced. The range and bearing dials on the front panel will now require resetting as described under "Alignment of Convertor".

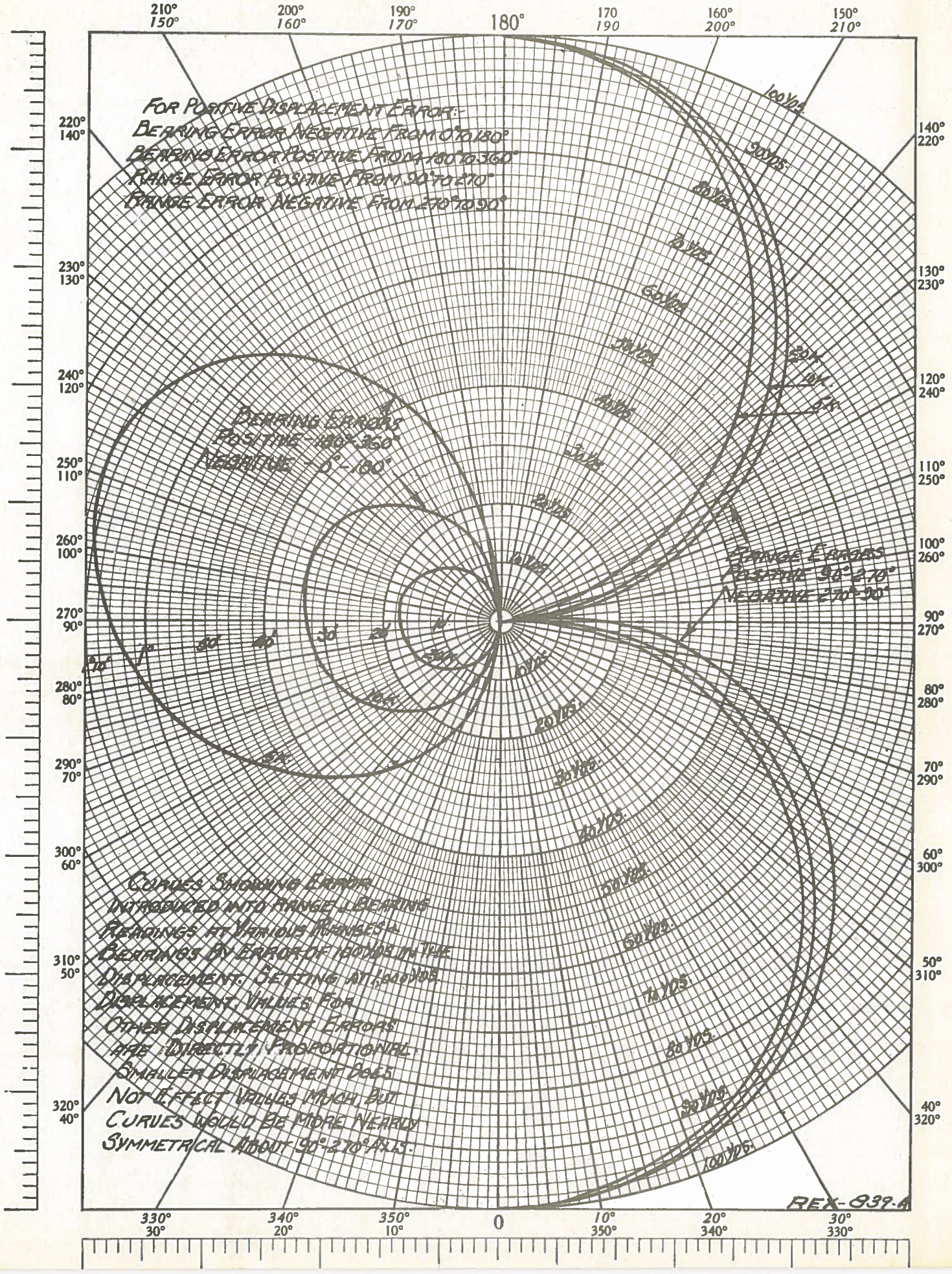
A test should then be run with the convertor, to check for accuracy and compared with the test made before disassembly. If this test is satisfactory, the dust cover can be replaced and the convertor placed in the rack.

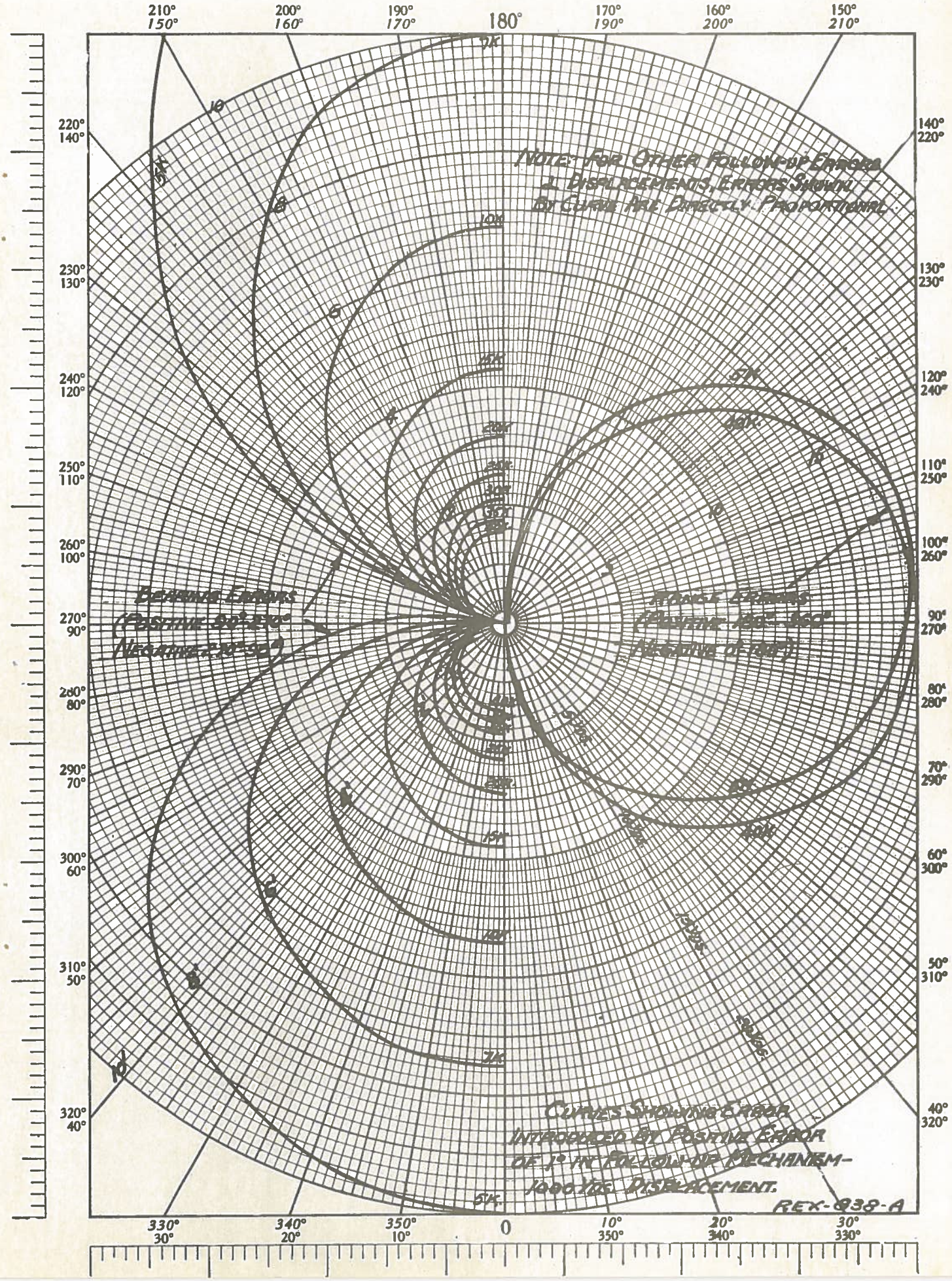
If the test curves of the convertor show serious errors, the following items should be checked:

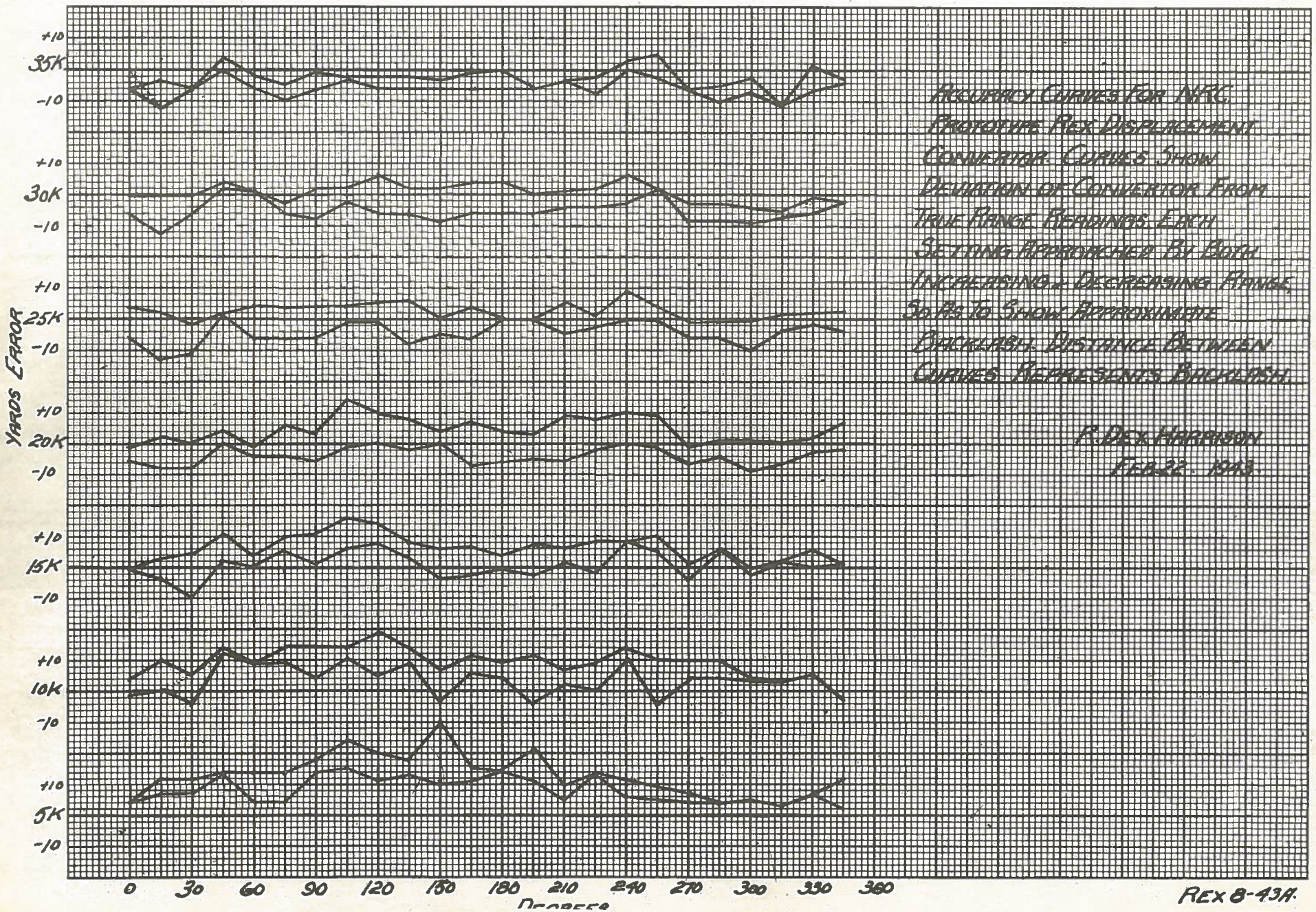
If the inaccuracies show up as an excessive variation from the true answer depending on sign for the direction in which the convertor is travelling to get the reading, all gear trains and the rack, lead screw and toggle should be checked for excessive play. The carriage should be checked for side play on the drill rod tracks. A good overall check can be made by rotating the handwheel and watching the vernier range magslip receiver. On reversing the handwheel, the magslip receiver should begin to move in the opposite direction in approximately 2/3 of a revolution of the handwheel, i.e. 12 yards approximately or ±6 yds. backlash. This check should be made at various ranges, in case the rack or lead screw are unevenly worn, or a gear has worn eccentric.

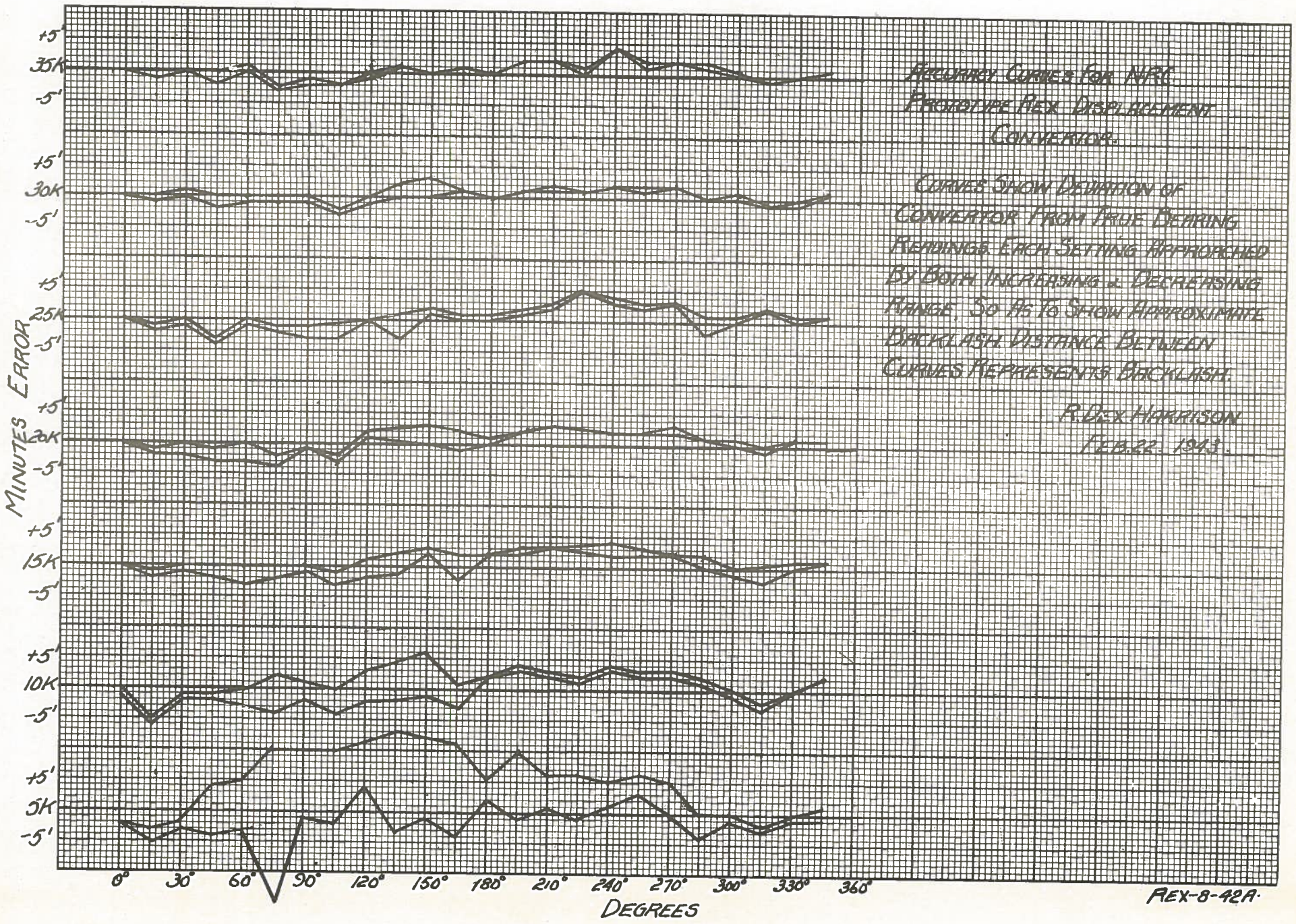
In the same manner, if the range is set at 5000 yards and the vernier bearing hunter magslip turned lightly in one direction and released and a reading taken on the vernier bearing magslip receiver and repeated after lightly turning and releasing in the opposite direction, the difference in reading should not exceed 10 minutes. At 25,000 yards, this value should be less than 2 minutes. If these values are exceeded, the gear train on top of the range carriage should be checked for excessive backlash, the side play of the rack between its guide bearings should be checked and the pivot bearing of the displacement crank examined for play. The yoke casting hanging from the range carriage should be checked to see that it is securely keyed to the shaft and free from side play in its bearings.

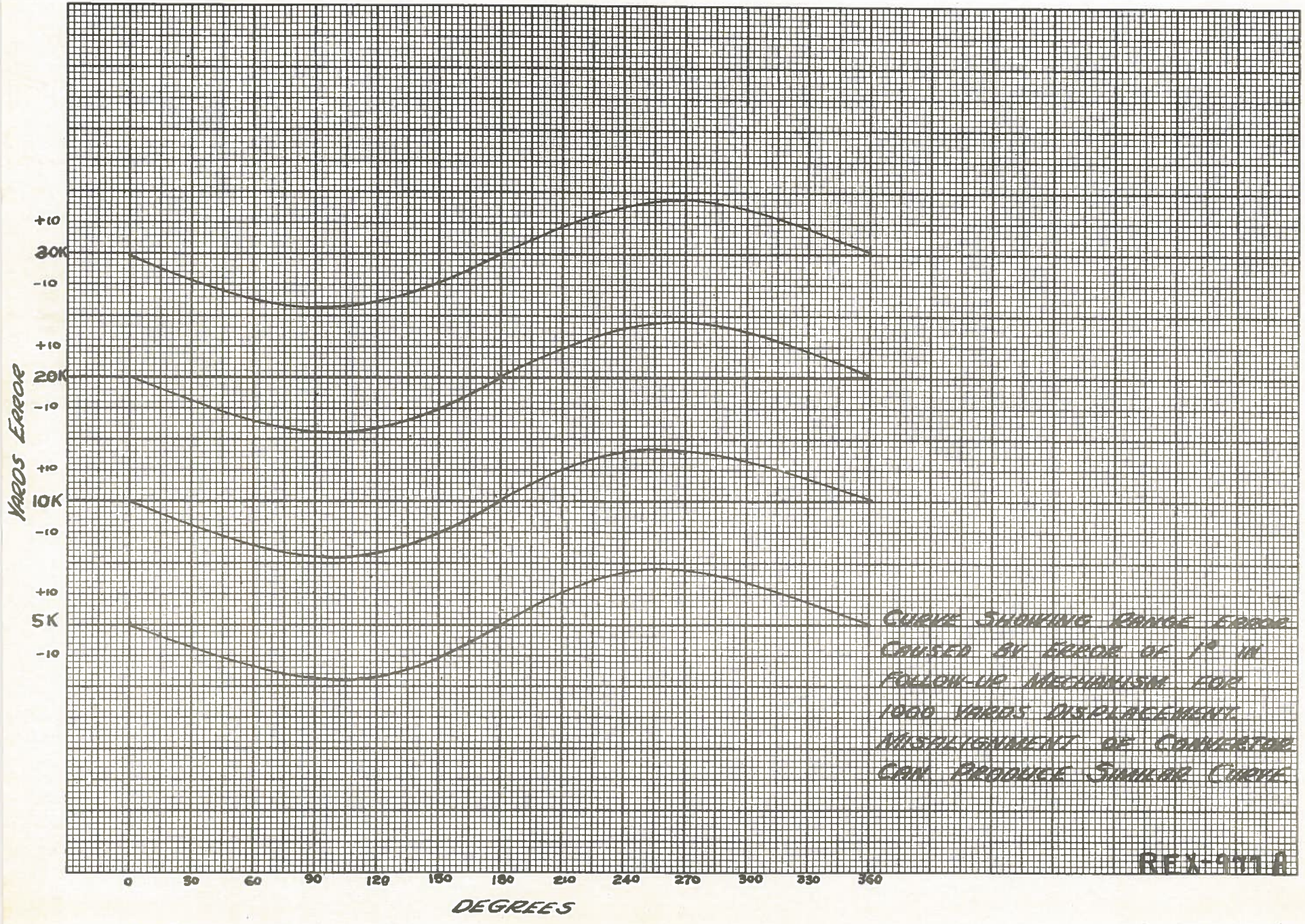
If the test curves show a regular curve, being accurate around 90° and 270° (measured from the base line) on the range test curves and being out around 0° and 180° and the bearing test curves show maximum error at 90° and 270° from the base-line, being accurate at 0° and 180°, then the displacement probably has been set incorrectly. Curve REX-839-A, shows gun range and bearing errors introduced by an error of 100 yards in the displacement setting. Curves REX-974 and 975 show the type of test curve obtained with this error.

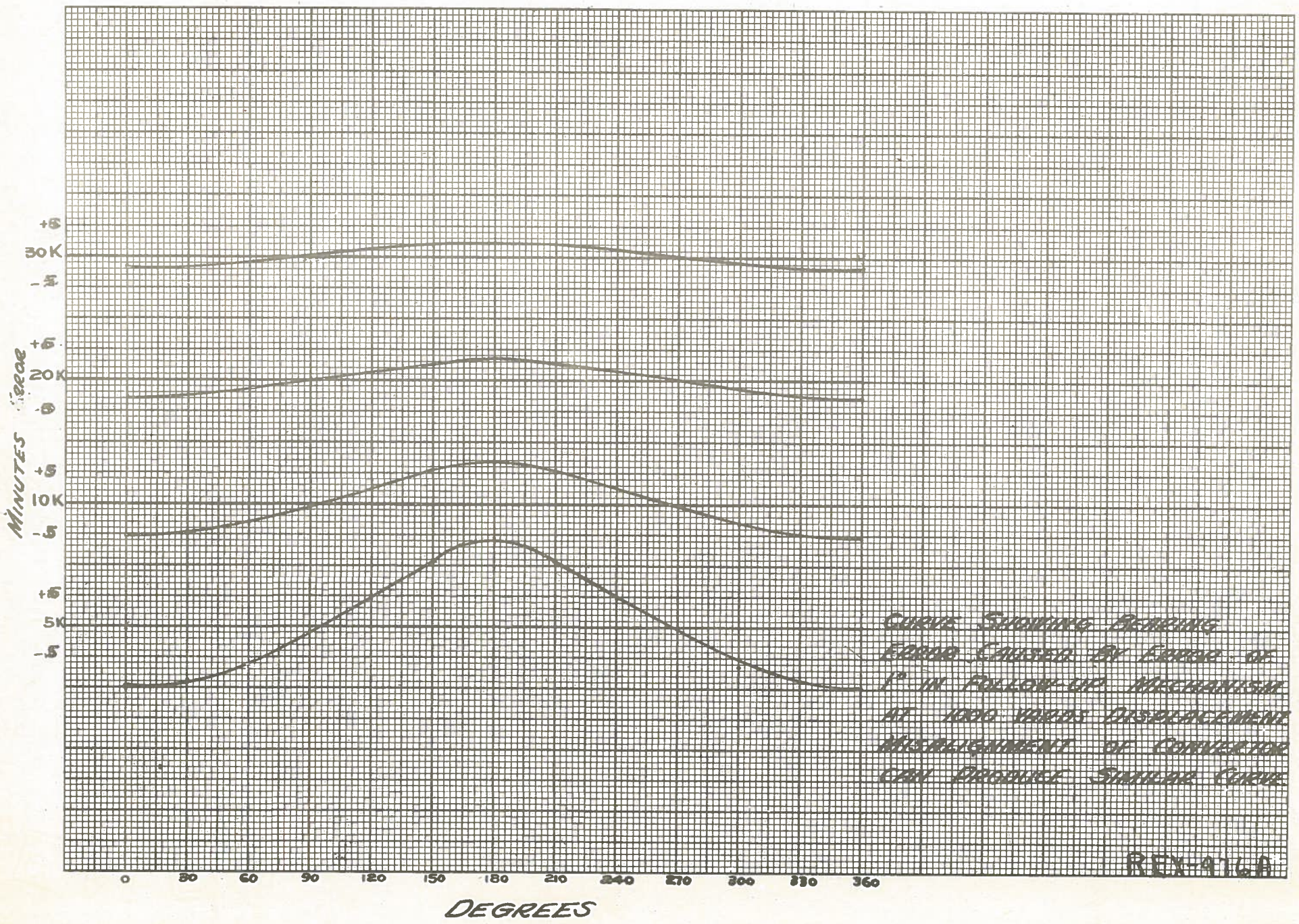

FOR POSITIVE DISPLACEMENT ERROR:
BEARING ERROR NEGATIVE FROM 0° TO 180°
BEARING ERROR POSITIVE FROM 180° TO 360°
RANGE ERROR POSITIVE FROM 90° TO 270°
RANGE ERROR NEGATIVE FROM 270° TO 90°
BEARING ERRORS
POSITIVE - 180°-360°
NEGATIVE - 0°-180°
RANGE ERRORS
POSITIVE 90°-270°
NEGATIVE 270°-90°
CURVES SHOWING ERROR INTRODUCED INTO RANGE & BEARING READINGS AT VARIOUS RANGES & BEARINGS BY ERROR OF 1 YD IN THE DISPLACEMENT SETTING AT 100 YDS.
DISPLACEMENT VALUES FOR OTHER DISPLACEMENT ERRORS ARE DIRECTLY PROPORTIONAL.
SMALLER DISPLACEMENT DOES NOT EFFECT VALUES MUCH, BUT CURVES WOULD BE MORE NEARLY SYMMETRICAL ABOUT 90°-270° AXIS.
REX-839-A

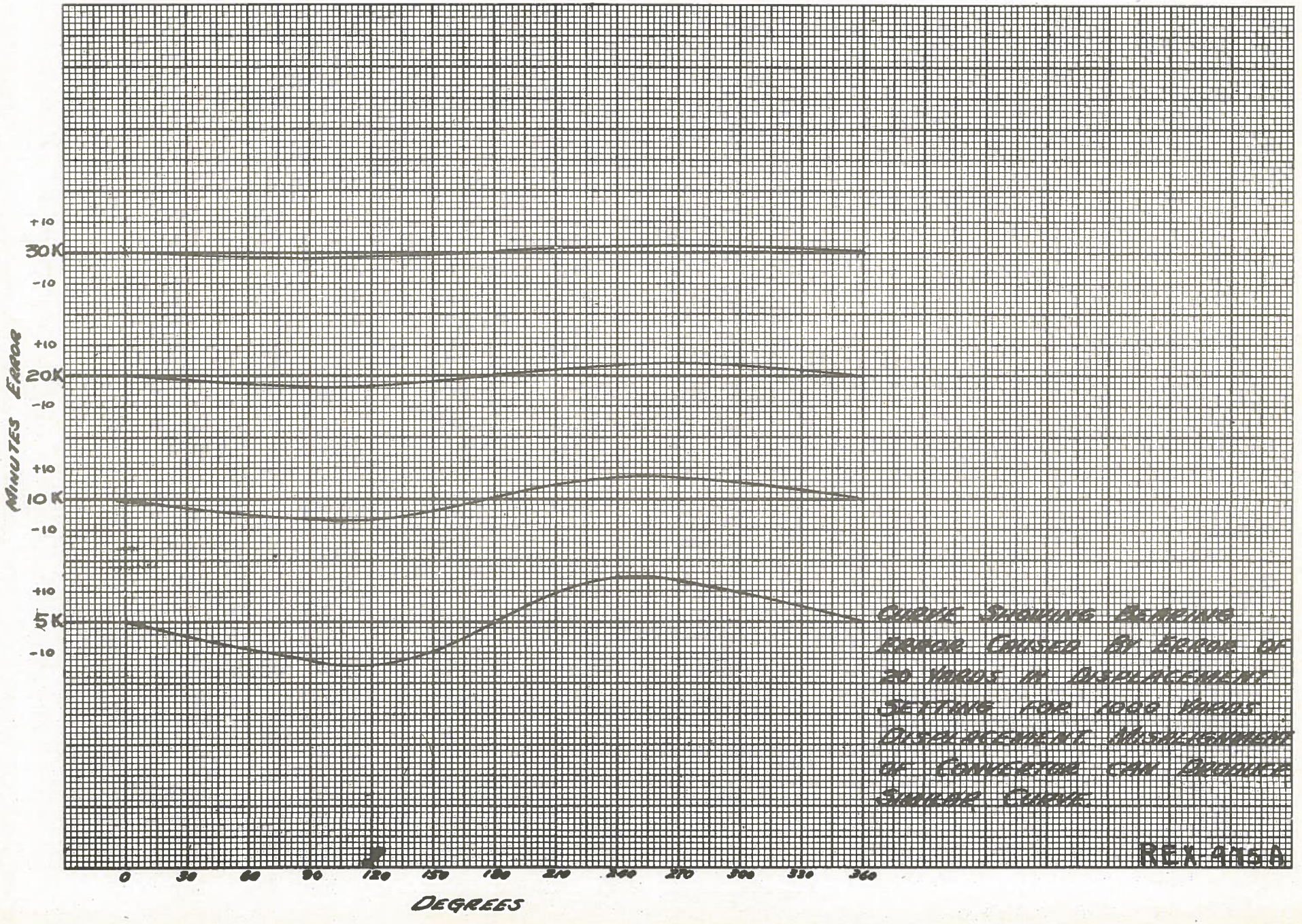

210° 150°
200° 160°
190° 170°
180°
170° 190°
160° 200°
150° 210°
220° 140°
230° 130°
240° 120°
250° 110°
260° 100°
270° 90°
280° 80°
290° 70°
300° 60°
310° 50°
320° 40°
330° 30°
340° 20°
350° 10°
0
10° 350°
20° 340°
30° 330°
140° 220°
130° 230°
120° 240°
110° 250°
100° 260°
90° 270°
80° 280°
70° 290°
60° 300°
50° 310°
40° 320°
NOTE: FOR OTHER FOLLOW-UP ERRORS & DISPLACEMENTS, ERRORS SHOWN BY CURVE ARE DIRECTLY PROPORTIONAL.
BEARING ERRORS (POSITIVE 90°-270° NEGATIVE 270°-90°)
SHAFT ERRORS (POSITIVE 180°-360° NEGATIVE 0°-180°)
CURVES SHOWING ERROR INTRODUCED BY POSITIVE ERROR OF 10° IN FOLLOW-UP MECHANISM— 1000 YDS. DISPLACEMENT.
REX-838-A

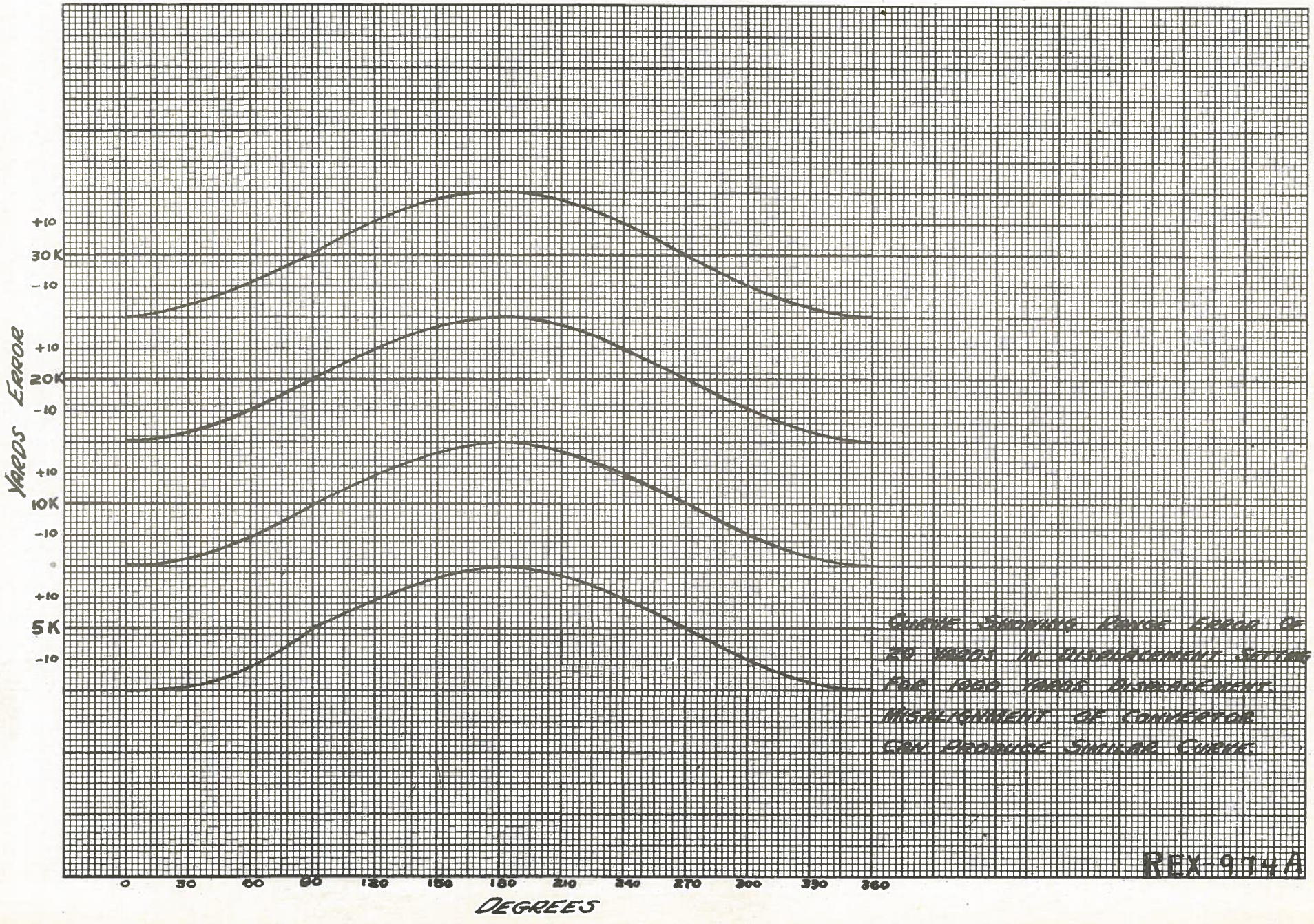

+10
35K
-10
+10
30K
-10
+10
25K
-10
+10
20K
-10
+10
15K
-10
+10
10K
-10
+10
5K
-10
YARDS ERROR
0
30
60
90
120
150
180
210
240
270
300
330
360
ACCURACY CURVES FOR NYK PROTOTYPE REX DISPLACEMENT CONVERTER. CURVES SHOW DEVIATION OF CONVERTER FROM TRUE RANGE READINGS. EACH SETTING APPROACHED BY BOTH INCREASING & DECREASING RANGE, SO AS TO SHOW APPROXIMATE BACKLASH. DISCLOSED DISTANCE BETWEEN CURVES REPRESENTS BACKLASH.
R. DEX HARRISON
FEB 22 1943
REX 8-43A.


+5'
35K
-5'
+5'
30K
-5'
+5'
25K
-5'
+5'
20K
-5'
+5'
15K
-5'
+5'
10K
-5'
+5'
5K
-5'
MINUTES ERROR
0°
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
360°
DEGREES
ACCURACY CURVES FOR NRL PROTOTYPE REX DISPLACEMENT CONVERTOR.
CURVES SHOW DEVIATION OF CONVERTOR FROM TRUE BEARING READINGS. EACH SETTING APPROACHED BY BOTH INCREASING & DECREASING RANGE, SO AS TO SHOW APPROXIMATE BACKLASH. DISTANCE BETWEEN CURVES REPRESENTS BACKLASH.
R. REX HARRISON
FEB. 22, 1943.
REX-8-42A.


+10
30K
-10
+10
20K
-10
+10
10K
-10
+10
5K
-10
YAROS ERROR
0
30
60
90
120
150
180
210
240
270
300
330
360
DEGREES
CURVE SHOWING RANGE ERROR CAUSED BY ERROR OF 1° IN FOLLOW-UP MECHANISM FOR 1000 YARDS DISPLACEMENT. MISALIGNMENT OF CONNECTOR CAN PRODUCE SIMILAR CURVE
REX-9171A


+6
30K
-6
+6
20K
0
+6
10K
-6
+6
5K
-6
MINUTES ERROR
0
30
60
90
120
150
180
210
240
270
300
330
360
DEGREES
CURVE SHOWING SCREW ERROR CAUSED BY ERROR OF 1" IN FOLLOW-UP MECHANISM AT 1000 YARDS DISPLACEMENT MISALIGNMENT OF CONNECTOR CAN PRODUCE SIMILAR CURVE
REX-916A


+10
30K
-10
+10
20K
-10
+10
10K
-10
+10
5K
-10
MINUTES ERROR
0
30
60
90
120
150
180
210
240
270
300
330
360
DEGREES
CURVES SHOWING MAXIMUM ERROR CAUSED BY ERROR OF 20 MILS IN ADJUSTMENT SETTING FOR 1000 MILS DISPLACEMENT. MEASUREMENT OF CORRECTION CAN DECREASE SHOWN CURVE.
REX 9/15/0


YARDS ERROR
+10
30K
-10
+10
20K
-10
+10
10K
-10
+10
5K
-10
0
30
60
90
120
150
180
210
240
270
300
330
360
DEGREES
CURVE SHOWING RADIAL ERROR OF 20 YARDS IN DISPLACEMENT SETTING PER 1000 YARDS DISPLACEMENT. MISALIGNMENT OF CONNECTOR CAN PRODUCE SIMILAR CURVE.
REX-914A

If, however, the curves are the reverse of this, i.e., range accurate at 0° and 180° (indicating correct displacement set in) and the bearing accurate at 90° and 270° being out at 0° and 180°, then the convertor range carriage or the displacement crank has got sprung out of line. As a check, it will be found that the test for 0° (running the carriage in and out, and watching the vernier gun bearing receiver) will not be exactly 180° away from the 180° point found in the same manner. Curves REX 976 and 977 show the test curves obtained when this condition exists.

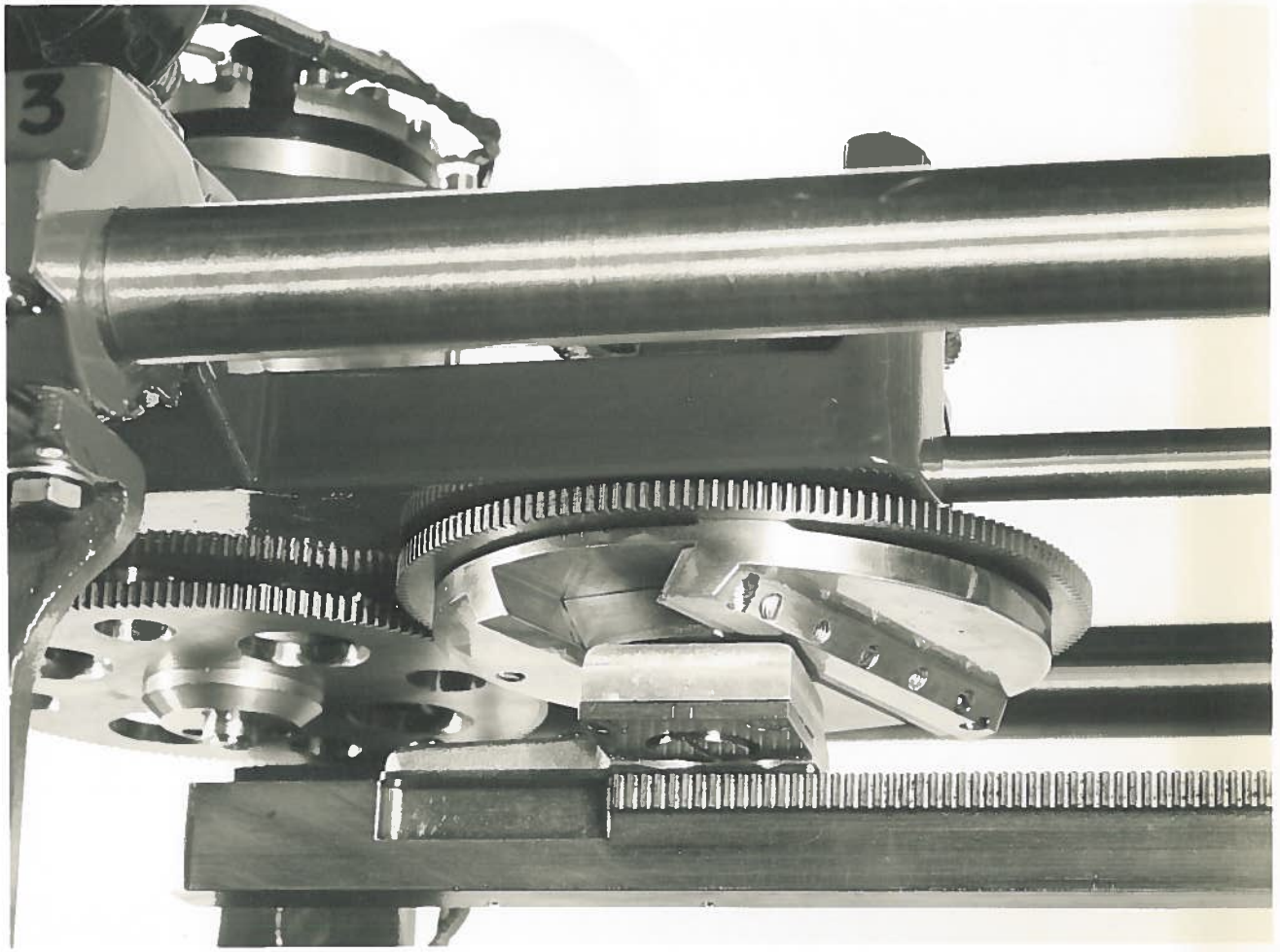
A maximum difference of about 30 minutes should be allowed. If the 0° reading is on the line, i.e. 0°00', then the reading for zero change of vernier bearing magslip receiver when running the carriage in and out should be between limits of 179°30' and 180°30'.

The cause for this type of error is a sideways displacement of the range carriage yoke casting or of the displacement slide crank.

It is possible, by excessive tightening of the set screws locking the displacement crank, (Photo 826 P), to actually bend the displacement crank casting, and thereby affect the accuracy. This can be checked by removing the rack and the ball-bearing on the crank and adjusting the shaft to zero displacement by means of a dial gauge placed against the displacement bearing shaft while rotating the casting. The displacement slide should not have an eccentricity exceeding .002". If it does, the fault should be traced down until the cause is discovered.

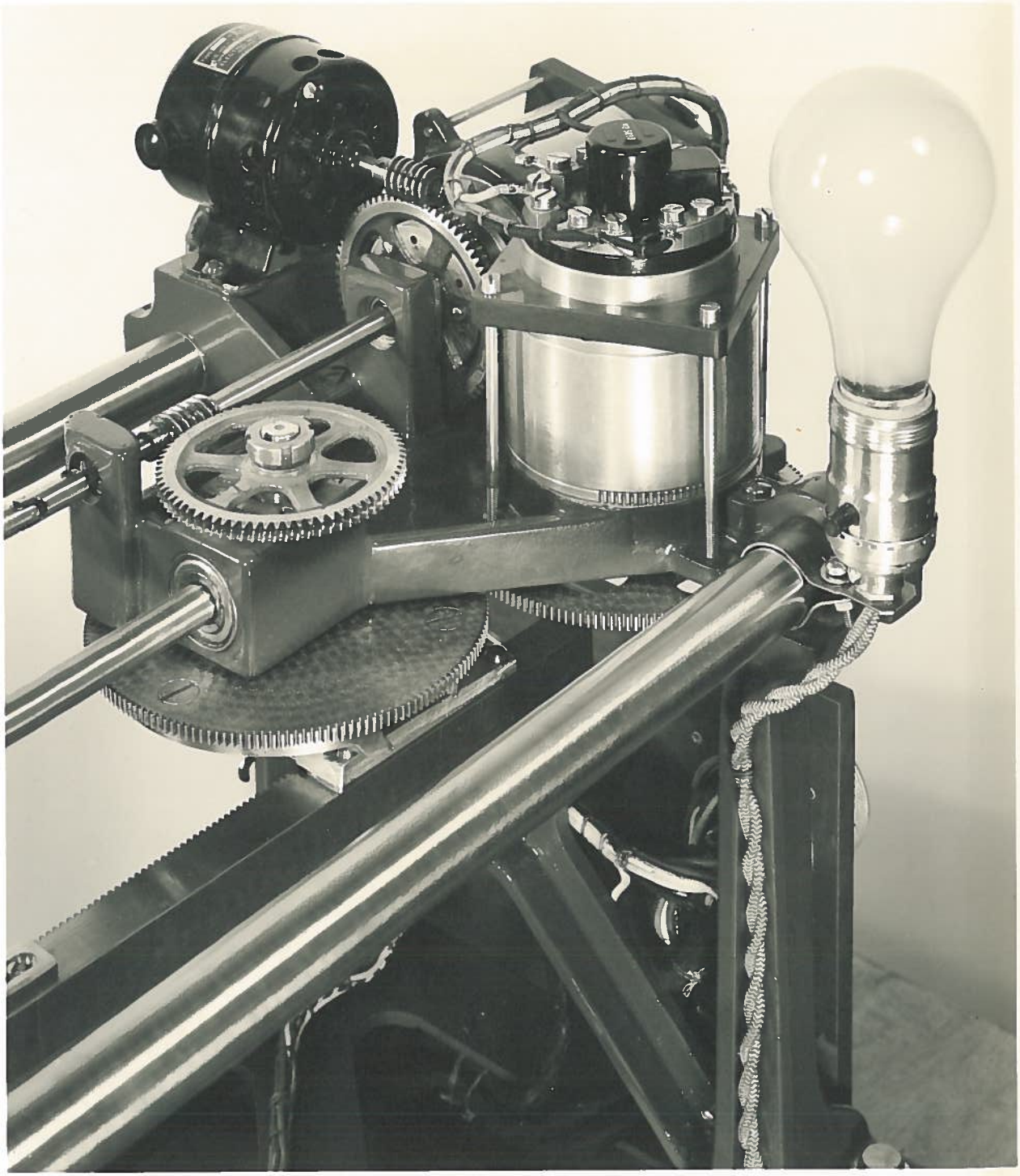
If the displacement crank passes this test satisfactorily, then the range carriage should be checked. If the zero checking wire slides through the shaft of the range crank and into the bearing displacement crank shaft easily when checking zero range, then the range carriage is in the center of the drill rod tracks. The yoke casting or its shaft can be bent, however.

This can be checked by removing the ball bearing retaining cap on the displacement slide crank and then carefully running the range carriage to zero range with the bearing set on the radar gun baseline and the toggle trip pin removed. The zero checking wire should be slid through the shaft on the range carriage and into the bearing displacement shaft. Then the bearing retaining screw in the centre of the displacement crank and the screw holding the gear to the vernier gun range magslip transmitter on the yoke casting should be very closely examined. They should be exactly in line when examined. A narrow scale would help in comparing these two points. They should not be more than .002" out of line, otherwise errors will arise. This type of error will also be caused by a very bad error in setting up the front dials with respect to the radar-gun baseline, or a very bad error in the follow-up when actually operating. Any serious back-lash in the bearing drive from the rear displacement crank casting to the front dials will also cause this type of error. Not more than five minutes error should exist between the two (as read on the front dials). This latter case would not effect the



DISPLACEMENT SLIDE CRANK & RACK

REX-826-P



BEARING FOLLOW-UP MECHANISM

FRONT ANGLE VIEW

REX-825-P

accuracy when operating with the follow up, but would make the front dial readings differ from the antenna bearing readings. The small couplings used on the small shaft running from the rear to the front of the convertor are one possible cause for this trouble. Curves showing error introduced by a one degree variation of the follow up mechanism are shown in curve REX 838 A.

APPENDIX

Test Specification REX-920

920.00 Test Connections

920.11 The displacement convertor is to be tested in a standard REX No. 1 rack.

.12 Use a range motor control chassis previously tested to satisfy Test Specification REX-912.

.13 Use a Servo chassis previously tested to satisfy Test Specification REX-903.

.14 Use an unregulated 300 volt power supply chassis previously tested to satisfy test Specification REX-915.

.15 The terminals corresponding to those numbered 271 to 278 on the prototype will be connected to a three-position test input switch in such a way as to make the following circuits:

Position "A"

271 to 274 to 277
272 to 275 to 278
273 and 276 open

Position "B"

272 to 275 to 277
273 to 276 to 278
271 and 274 open

Position "C"

273 to 276 to 277
271 to 274 to 278
272 and 275 open

.16 The rack is to be energized with 115 ± 1 volt A.C.

.17 A load resistor is to be connected between the high voltage line and ground, of such a value as to bring the output of the unregulated power supply to between 285 and 300 volts D.C.

.18 The convertor output is to be read on bearing and range magslip test boxes.

920.20 Alignment of Displacement Convertor

.21 Lining up the Magslip Test Boxes

Set the Test Input Switch to position A. Plug the range and bearing magslip test boxes into their outlets on the bottom panel of the rack. Set the switch on the bearing magslip test box to "Radio Bearing". Turn the magslip power switch on. Now adjust the bearing magslips to read 120° 00' and the range magslips to read 20,000 yards. Coarse adjustment should be made by turning the pointers, and the final alignment completed by loosening the magslip clamps and turning the casing.

.22 Adjustment of Convertor Radio Range Dials

Run the carriage to 35,000 yards, and set the displacement crank pin directly behind the displacement shaft. Remove the set-screws holding the displacement slide in place and withdraw the gun range rack and displacement slide from the convertor. Run the carriage carefully to zero. This zero setting is determined on the prototype model by aligning two New Departure lock nuts, one on the carriage pivot and the other on top of the displacement shaft. On production models an aligning pin is inserted through holes in the centres of the carriage pivot and the displacement shaft. Set the Radio Range pointers on the front panel of the convertor to read zero range when the carriage is in this position. Run the range to 35,000 yards and replace the gun range rack. Set in a displacement of approximately half an inch on the crank slide (corresponding to 1000 yards).

.23 Displacement Adjustment

Put the bearing magslip test box to "Gun Bearing". Set the radio range at approximately 15,000 yards, as read on convertor dials. Put the convertor "operate-check" switch to "check" and, by using the "right-left" switch and speed control, swing the radio bearing through 360 degrees while watching the vernier gun range magslip dial for a maximum change of range. The position of the displacement crank should be adjusted until the maximum observed change of range is twice the desired displacement. A test displacement of 1000 yards should be used.

.24 Adjustment of Radio Bearing Dials on Convertor

With the displacement crank pin directly behind the displacement shaft, and with a displacement of 1000 yards set in as in the above paragraph, run the carriage from 25,000 yards to 5000 yards, observing the vernier gun bearing magslip receiver. The radio bearing should be changed and this procedure repeated until no change of gun bearing is observed when the range is run from 5000 to 25,000 yards. A change of 15' in the setting of the vernier

radio bearing dial should cause a perceptible movement in the vernier gun bearing dial when the range is changed, so that the target, radio, and gun points should be lined up within 15'.

This position has arbitrarily been called zero for test purposes. Set the Radio Bearing pointers on the front panel of the convertor to read 0° 00' accurately.

.25 Adjustment of Bearing Magslip Hunters

With the radio bearing set at zero as in the above paragraph, run the carriage out to 15,000 yards. Set the Test Input Switch to Position A (120° 00') and ensure that the switch on the bearing magslip box is set to "Gun Bearing". Loosen the hunter magslip clamps and adjust the main hunter until the main gun bearing dial reads 120°. Similarly adjust the vernier hunter until the vernier gun bearing dial reads 0° 00'.

.26 Adjustment of Gun Range Transmitter Magslips

With the radio bearing still set at zero as in the paragraph "Adjustment of Radio Bearing Dials on Convertor" run the carriage out to 14,000 yards radio range. Adjust the main and vernier gun range magslip transmitters on the carriage until the gun range test box dials read 15,000 yards.

920.30 Servo System Adjustment

.310 Alignment of Servo Magslip Nulls

.311 Put the main and vernier channel Servo on-off switches to "off".
.312 Put the test input switch to position A.
.313 Turn the convertor to radio bearing 120° 00', as read on the front panel.
.314 Use an oscillograph to measure the voltage between the terminals of the servo magslips.
.315 Connect together terminals 2 and Y of the main and terminals 3 and Y of the vernier servo magslip.
.316 Loosen the mounting of the main servo magslip and turn the body of the magslip until there is zero voltage between terminals X and Y. Now put the oscillograph across terminals 1 and X and see whether the voltage increases when the magslip casing is turned clockwise from the null position. If it decreases, then turn the magslip 180° and use the other null.
Tighten up the mounting to clamp the magslip exactly on the null position.

.317 Next, loosen the mounting of the vernier servo magslip and turn the body of the magslip until there is zero voltage between terminals X and Y. Put the oscillograph across terminals 1 and X and see whether the voltage increases when the magslip casing is turned counterclockwise from the null position. If it decreases, then turn the magslip 180° and use the other null.

Tighten up the mounting to clamp the magslip exactly on the null position.

.320 Adjustment of Servo Chassis Controls

.321 To turn the convertor away from the Servo Magslip null positions, put the convertor operate-check switch to "check" and use the right-left switch and speed control rheostat to move the bearing motor. Read the angles on the radio bearing dial of the front panel.

. To allow the Servo system to assume control, return the operate-check switch to "operate".

.322 Put the main channel servo on-off switch to "off", and the vernier switch to "on".

Turn the convertor 2° off the vernier magslip null, return the system to servo control, and hold the motor shaft to prevent it from turning back.

Set the vernier channel gain control about half way, and adjust the vernier channel phase control to give maximum torque on the motor.

Release the motor shaft and it should turn the convertor to within 5' of the null at 120° 00'.

.323 Advance the gain control until hunting occurs. Then reduce the gain just below the point where the motor will move from at least 1° off the null in to the null with no hunting action.

.324 Next, turn the vernier channel off and the main channel on. Set the threshold control to zero bias. Move the convertor to 140°, return the system to servo control, and hold the motor shaft. Turn the main channel gain about halfway, and adjust the main channel phase control to give maximum torque.

.325 Now set the threshold control to full bias, and turn the convertor to 125°. Decrease the bias very gradually and the convertor should approach 120°. Leave the bias control at the point which puts the convertor at 121° 30'.

Check that the Servo just begins to develop torque as the convertor moves past 121° 30'.

.326 Turn the convertor to 240°, and as the motor is driving it towards the null re-adjust the main channel phase control for maximum speed.

Check the setting on the threshold control again as given above.

.3271 Now turn both main and vernier channels off, and turn the convertor to 130°. Turn both channels on simultaneously, and the convertor should return to within 5' of 120° without hunting.

.3272 Repeat 920.3271 from 110°

.3273 Repeat 920.3271 from 150°

.3274 Repeat 920.3271 from 90°

.328 Check that the convertor passes smoothly through the settings 127° 30' and 112° 30'. If it should stall at these settings, increase the main channel gain slightly until the condition is remedied.

.329 Check that the convertor will align itself properly from several random points not between 298° and 302°.

If the convertor is put within 1° or 2° of 300°, then the Servo should align it at 300°.

.330 Test of Magslip Wiring

.331 Next, turn the vernier channel switch off, and put the Test Input Switch to position B. The convertor must turn to a position between 238° 30' and 241° 30'.

.332 Put the Test Input switch to position C. The convertor must turn to a position between 358° 30' and 1° 30'.

.333 Now turn off the main channel and turn on the vernier channel. The convertor must turn to a position reading between 6° 35' and 6° 45' on the vernier dial.

.334 Put the test input switch to position B. The convertor must turn to a position reading between 3° 15' and 3° 25' on the vernier dial.

920.40 BACKLASH

.41 Remove the range motor control chassis. Connect the oscilloscope across two stator leads of the vernier gun range magslip transmitter, turn on the magslip power and operate the slow speed range slewing switch until the oscilloscope shows an approximate voltage null. Complete the adjustment by rotating the range handwheel slowly in one direction until the null is obtained.

To measure the backlash through the range gearbox to the transmitter magslip, turn the range handwheel in the opposite direction until the voltage starts to build up again. This backlash should not exceed 120° of handwheel rotation.

920.50 Range Rate

.51 Replace the range motor control chassis. Use the Range Motor Adjustment to set the position of the handwheel, where the motor just starts, at 45° on either side of the zero position.

.52 Check the speeds of the range motors using the radio range dials and a stop watch. They must fall within the limits stated in the following paragraphs.

.53 With the range handwheel rotated fully clockwise the range following motor must drive the convertor at a rate between 1760 and 2000 yards per minute, range increasing.

.54 With the range handwheel rotated fully counterclockwise the range must decrease at a rate between 1760 and 2000 yards per minute.

.55 With the Fast Slewing Switch closed to the right, the range slewing motor must drive the convertor at a rate between 80,000 and 120,000 yards per minute, range increasing.

.56 With the Fast Slewing Switch closed to the left, the range must decrease at a rate between 80,000 and 120,000 yards per minute.

.57 With the Slow Slewing Switch closed to the right, the range slewing motor must drive the convertor at a rate between 8,000 and 12,000 yards per minute, range increasing.

.58 With the Slow Slewing Switch closed to the left the range must decrease at a rate between 8,000 and 12,000 yards per minute.

920.60 Microswitch Settings

.61 Test the reversing switches on the range rate rheostat. They must reverse the range motor within 1° of the electrical center tap of the rheostat, measured as 0.016 inches on the cam periphery.

.62 Find the readings on the radio range dials when the range limit microswitches open the range motor circuits. The switches should open at a minimum range between -1500 and -500 yards, and at a maximum range between 37,000 and 39,000 yards.

.63 Run the carriage in past the minimum gun range setting of 5000 yards and check that the toggle trips, its microswitch turns off the right hand green panel light, and the gun range and bearing dials on the test box go to 20,000 yards and 120° 00'.

.64 Check that both green panel lights go off, and the gun range and bearing dials go to 20,000 yards and 120° 00' when the magslip power switch on the panel is turned off.

920.70 Torque

.71 Set the radio range and bearing to 10,000 yards and 90° respectively.
.72 Turn off the power input to the convertor.
.73 Measure the torque that must be applied to the range handwheel in order to drive the range mechanism. This must be between 2 in. oz. and 6 in. oz.
.74 Replace the range following motor by an extension shaft, and measure the torque that must be applied to the shaft in order to drive the range mechanism. This torque must not exceed 1 1/2 in. oz.

.75 Replace the range slewing motor by an extension shaft, and measure the torque that must be applied to the shaft in order to drive the range mechanism. This torque must not exceed 12 in. oz.

920.80 Calibration Test

.81 Ensure that the convertor is aligned on 0° 00' bearing and 1000 yards displacement.

.82 Put the main and vernier channel Servo on off switches to "off".

.83 Put the Test Input Switch to position A.

.84 Put the switch on the bearing magslip box to "gun bearing".

.85 Put the convertor operate check switch to "check" and use the right left switch and speed control rheostat to set the radio Bearing Dial to the values in the "Displacement Convertor Test Table" below. Run in the indicated radio ranges and record the output range and bearing readings of the magslip test boxes.

.86 Displacement Convertor Test Table

.87 Plot curves showing the deviations between the convertor gun range and bearing outputs and the true values shown in the table.

The gun ranges must not vary from the true values by more than 10 yards.

The gun bearing error curve must fall within the limits specified on curve REX 889 A.

920.86 Cont'd

DISPLACEMENT CONVERTOR TEST TABLE

Displacement ..... 1000 yards
Bearing of R.D.F. set from Battery Pivot ..... 0° 00'

Radio Bearing	Radio Range	Correct Output Bearing	Observed Output Bearing	Bearing Error	Correct Output Range	Observed Output Range	Range Error
	5000	120° 00'			6000		
	7000	120° 00'			8000		
	10000	120° 00'			11000		
0° 00'	15000	120° 00'			16000		
	20000	120° 00'			21000		
	25000	120° 00'			26000		
	30000	120° 00'			31000		
	35000	120° 00'			36000		
	5000	117° 31'			5972		
	7000	118° 08'			7970		
	10000	118° 39'			10969		
15° 00'	15000	119° 04'			15968		
	20000	119° 18'			20968		
	25000	119° 25'			25967		
	30000	119° 32'			30967		
	35000	119° 36'			35967		
	5000	115° 07'			5887		
	7000	116° 22'			7882		
	10000	117° 22'			10878		
30° 00'	15000	118° 12'			15874		
	20000	118° 38'			20872		
	25000	118° 54'			25871		
	30000	119° 04'			30870		
	35000	119° 12'			35870		
	5000	112° 56'			5751		
	7000	114° 46'			7739		
	10000	116° 13'			10730		
45° 00'	15000	117° 25'			15723		
	20000	118° 03'			20719		
	25000	118° 26'			25717		
	30000	118° 41'			30715		
	35000	118° 52'			35714		

Radio Bearing	Radio Range	Correct Output Bearing	Observed Output Bearing	Bearing Error	Correct Output Bearing	Observed Output Range	Range Error
	5000	111° 03'			5568		
	7000	113° 25'			7550		
	10000	115° 17'			10536		
60° 00'	15000	116° 48'			15524		
	20000	117° 35'			20518		
	25000	118° 03'			25515		
	30000	118° 22'			30512		
	35000	118° 36'			35511		
	5000	109° 36'			5347		
	7000	112° 25'			7323		
	10000	114° 37'			10304		
75° 00'	15000	116° 23'			15289		
	20000	117° 16'			20282		
	25000	117° 49'			25277		
	30000	118° 10'			30274		
	35000	118° 26'			35272		
	5000	108° 41'			5099		
	7000	111° 52'			7071		
	10000	114° 17'			10050		
90° 00'	15000	116° 11'			15033		
	20000	117° 08'			20025		
	25000	117° 43'			25020		
	30000	118° 05'			30017		
	35000	118° 22'			35014		
	6000	110° 27'			5822		
	8000	112° 53'			7801		
	10000	114° 20'			9789		
105° 00'	15000	116° 15'			14773		
	20000	117° 12'			19765		
	25000	117° 46'			24760		
	30000	118° 08'			29757		
	35000	118° 24'			34755		
	6000	111° 03'			5568		
	8000	113° 25'			7550		
	10000	114° 48'			9539		
120° 00'	15000	116° 35'			14526		
	20000	117° 27'			19519		
	25000	117° 59'			24515		
	30000	118° 19'			29513		
	35000	118° 34'			34511		

Radio Bearing	Radio Range	Correct Output Bearing	Observed Output Bearing	Bearing Error	Correct Output Range	Observed Output Range	Range Error
	6000	112° 24			5339		
	8000	114° 28			7327		
	10000	115° 39			9320		
135° 00	15000	117° 10			14310		
	20000	117° 54			19306		
	25000	118° 20			24303		
	30000	118° 37			29301		
	35000	118° 49			34300		
	6000	114° 26			5158		
	8000	116° 00			7151		
	10000	116° 52			9148		
150° 00	15000	117° 58			14143		
	20000	118° 30			19140		
	25000	118° 49			24139		
	30000	119° 01			29138		
	35000	119° 10			34138		
	6000	117° 03			5041		
	8000	117° 54			7039		
	10000	118° 22			9038		
165° 00	15000	118° 57			14036		
	20000	119° 13			19036		
	25000	119° 23			24035		
	30000	119° 29			29035		
	35000	119° 34			34035		
	6000	120° 00			5000		
	8000	120° 00			7000		
	10000	120° 00			9000		
180° 00	15000	120° 00			14000		
	20000	120° 00			19000		
	25000	120° 00			24000		
	30000	120° 00			29000		
	35000	120° 00			34000		
	6000	122° 57			5041		
	8000	122° 06			7039		
	10000	121° 39			9038		
195° 00	15000	121° 03			14036		
	20000	120° 47			19036		
	25000	120° 37			24035		
	30000	120° 31			29035		
	35000	120° 26			34035		

Radio Bearing	Radio Range	Correct Output Bearing	Observed Output Bearing	Bearing Error	Correct Output Range	Observed Output Range	Range Error
	6000	125° 34'			5158		
	8000	124° 01'			7151		
	10000	123° 08'			9148		
210° 00'	15000	122° 02'			14143		
	20000	121° 30'			19140		
	25000	121° 11'			24139		
	30000	120° 59'			29138		
	35000	120° 50'			34138		
	6000	127° 37'			5339		
	8000	125° 32'			7327		
	10000	124° 21'			9320		
225° 00'	15000	122° 50'			14310		
	20000	122° 06'			19306		
	25000	121° 40'			24303		
	30000	121° 23'			29301		
	35000	121° 11'			34300		
	6000	128° 57'			5568		
	8000	126° 35'			7550		
	10000	125° 13'			9539		
240° 00'	15000	123° 25'			14526		
	20000	122° 33'			19519		
	25000	122° 01'			24515		
	30000	121° 41'			29513		
	35000	121° 26'			34511		
	6000	129° 33'			5822		
	8000	127° 07'			7801		
	10000	125° 40'			9789		
255° 00'	15000	123° 45'			14773		
	20000	122° 48'			19765		
	25000	122° 14'			24760		
	30000	121° 52'			29757		
	35000	121° 36'			34755		
	5000	131° 19'			5099		
	7000	128° 08'			7071		
	10000	125° 43'			10050		
270° 00'	15000	123° 49'			15033		
	20000	122° 52'			20025		
	25000	122° 17'			25020		
	30000	121° 55'			30017		
	35000	121° 38'			35014		

Radio Bearing	Radio Range	Correct Output Bearing	Observed Output Bearing	Bearing Error	Correct Output Range	Observed Output Range	Range Error
	5000	130° 25'			5347		
	7000	127° 35'			7323		
	10000	125° 23'			10304		
285° 00'	15000	123° 37'			15289		
	20000	122° 44'			20282		
	25000	122° 11'			25277		
	30000	121° 50'			30274		
	35000	121° 34'			35272		
	5000	128° 57'			5568		
	7000	126° 35'			7550		
	10000	124° 43'			10536		
300° 00'	15000	123° 12'			15524		
	20000	122° 25'			20518		
	25000	121° 57'			25515		
	30000	121° 38'			30512		
	35000	121° 24'			35511		
	5000	127° 04'			5751		
	7000	125° 15'			7739		
	10000	123° 47'			10730		
315° 00'	15000	122° 35'			15723		
	20000	121° 57'			20719		
	25000	121° 35'			25717		
	30000	121° 19'			30715		
	35000	121° 08'			35714		
	5000	124° 53'			5887		
	7000	123° 38'			7882		
	10000	122° 38'			10878		
330° 00'	15000	121° 48'			15874		
	20000	121° 22'			20872		
	25000	121° 06'			25871		
	30000	120° 56'			30870		
	35000	120° 48'			35870		
	5000	122° 29'			5972		
	7000	121° 52'			7970		
	10000	121° 21'			10969		
345° 00'	15000	120° 56'			15968		
	20000	120° 42'			20968		
	25000	120° 35'			25967		
	30000	120° 28'			30967		
	35000	120° 24'			35967		

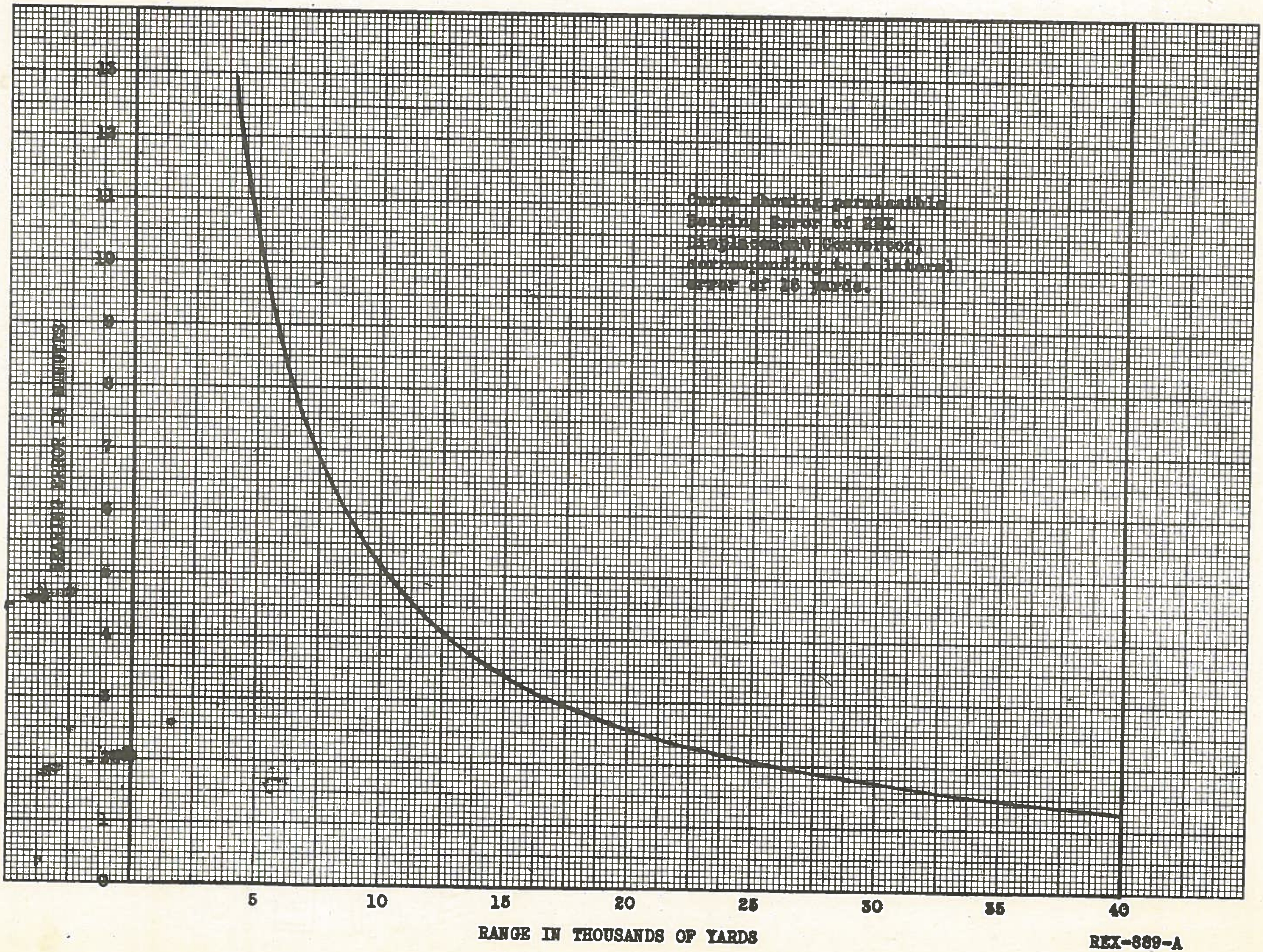
920.90 Test of Battery Magslip Power Relay

Set Magslip Power Switch to "OFF".
Connect the following pairs of terminals together:-

Terminal 237 to terminal 293.
Terminal 229 to terminal 294.

The completion of these connections will apply 55 volts to the relay coil.

The operation of the relay is to be checked by observing that the orange pilot light over the convertor is turned on.


Curve showing permissible
Bearing Error of REX
Displacement Converter,
corresponding to a lateral
BEARING ERROR IN MINUTES
0
1
2
3
4
5
6
7
8
9
10
11
12
13
5
10
15
20
25
30
35
40
RANGE IN THOUSANDS OF YARDS

REX-889-A