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SUBJECT

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Dummy Log Equipment Type DI-40

by

P. H. Roeser

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NAVY DEPARTMENT

Report of Test

on

FR-2283

DUMMY LOG EQUIPMENT

Type DL-40

Submitted by

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Bendix Aviation Corporation
Baltimore, Maryland

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AUTHORIZATION FOR TEST

1. This problem was authorized by reference (a), and other references pertinent to this problem are listed as references (b) to (g) inclusive.

- Reference (a) BuShips ltr. NObs-12433(335)S65-5 of 8 February 1944 to Director, NRL.
- (b) Contract NObs-12433.
- (c) BuShips ltr. NObs-13011(665)-NObs-12433 of 6 May 1944 to Director, NRL.
- (d) Specification SGS(65)-151a of 1 February 1937.
- (e) Specification 17Ell(INT) of 15 May 1943.
- (f) Friez Drwg. No. V-40255, Dummy Log Speed Transmitter.
- (g) Friez Drwg. No. V-40256, Dummy Log Distance Transmitter.

OBJECT OF TEST

2. The object of this test was to determine conformance of the sample equipment with contract, reference (b), as modified by reference (c), and with specifications, references (d) and (e), and its suitability for Naval use.

ABSTRACT OF TEST

3. The sample Dummy Log (Speed Transmitter and Distance Transmitter) was set up at this Laboratory in conjunction with suitable testing equipment and its performance was carefully observed for compliance with the contract and its modifications and the specifications. An inspection of the sample to determine compliance in the matter of materials, design, and workmanship, concluded the test.

CONCLUSIONS

From the tests conducted on the laboratory models of the Friez Type DL-40 Dummy Log Equipment, the following may be concluded:

- (a) Since the units of the equipment are laboratory models, some of the defects noted may readily be corrected when the equipment is on a production basis, namely,

Speed Transmitter

- (1) The leak around the shaft of the hand crank.
- (2) The leak around the cover gasket.
- (3) The fracture of the dial.
- (4) Painting of enclosure.

Distance Transmitter

- (5) The derangement of the contacts in the reversible motor circuit.
- (6) The increased friction in the reversible motor gear train.
- (7) The loosening of the nut on the bottom of the constant speed disc carriage. It is understood that this nut, on production equipment, is to be cast integral with the frame of the carriage.
- (8) The loosening of the lead screw head in the frame, permitting end-play.
- (9) Bending of the disc shaft out of alignment.
- (10) Painting of enclosure.

- (b) However, it is felt that in some instances, design changes should be made to better the overall operation of the equipment, namely,

Speed Transmitter

- (1) Better means of relamping.
- (2) Change air-vane damping device to limit the rate of speed change to 8 knots per minute. It is possible to rotate the hand crank at a rate that is high enough to cause the roller in the contact mechanism to pass over the end of the heart-shaped cam. This reverses the positioning motor and causes the disc to be positioned incorrectly on the roller, producing erroneous "distance outputs".
- (3) Provide means of preventing the hand crank from being turned while the system is not energized. This displaces the rotor in the generator of the speed transmitter without the corresponding action of rotor in the self-synchronous motor in the distance transmitter. This displacement can be great enough that, when the system is energized, the motor will rotate sufficiently to permit the roller to pass over the end of the heart-shaped cam. Erroneous "distance outputs" are then produced, as was described above.

Distance Transmitter

- (4) Wiring between component parts should be better placed to prevent interference with operation.

CONCLUSIONS (CONTD.)

- (5) Add skirts to bottom vent ports in case cover.
 - (6) Add screens in top vents to prevent the entry of vermin.
 - (7) Provide separable terminal strips to facilitate inspection and oiling which must be done very frequently.
- (c) Due to the many probable differences between the laboratory models and the production equipment a check of the equipment against the manufacturer's drawings has been deferred until the anticipated return for test following modifications.

RECOMMENDATIONS

(a) That the Friez Dummy Log Speed Transmitter, Type DL-40, be approved for this contract subject to correction of defects noted herein.

(b) That approval of the Friez Dummy Log Distance Transmitter, Type DL-40, be withheld pending correction of deficiencies.

(c) It is further recommended that complete contract suitability tests be conducted on production samples of both units after the equipment has been modified to correct deficiencies.

(d) That the major part of the oscillatory action described, as occurring in components of the distance transmitter, be eliminated. If modifications to the equipment are made, it is suggested that the following be considered:

- (1) Replace the shaded - pole motor, now used, with a motor, the speed of which can be more closely adjusted. It is very desirable to have the motor speed approximate the speed of the roller instead of depending upon the roller and disc to burden the motor and thus contribute to the speed regulation.
- (2) Provide a mechanical gear train between the shaded-pole motor and the type "B" generator that will prevent the oscillatory action in the loading motor from being reflected past the type "B" generator. A worm and worm-wheel type of drive with adequate thrust-bearings would be desirable. Any frictional type damping should be avoided due to its susceptibility to wear and subsequent loss of control.

DESCRIPTION OF MATERIAL

4. The Type DL-40 Dummy Log System submitted for test is laboratory model equipment and is comprised of two (2) separate units known as the Dummy Log Speed Transmitter and the Dummy Log Distance Transmitter, respectively. The speed transmitter is provided with a manual control and is designed to operate all units that indicate speed by an angular position. The distance transmitter, when electrically connected to the speed transmitter, converts the angular positions supplied into rotary motion, the speed of which is proportional to the angular setting. This system can be used as a substitute for a Ships Underwater Log System, only where it is possible to ascertain or estimate the ship's speed by other means. When so used, the speed transmitter positions all equipment giving angular speed indications (or requiring angular changes in proportion to speed) and the distance transmitter supplies the rotary motion distance component for the Dead Reckoning Analyzer.

DUMMY LOG SPEED TRANSMITTER - DRWG. NO. V-40255

5. The speed transmitter consists of a type "B" self-synchronous generator, equipped with a suitable dial and gear train, all housed in a watertight cast aluminum case for bulkhead mounting. A hand crank is provided in the case cover as a means for rotating the generator and dial. An air-vane type damping device is provided in the gear train to prevent (by limiting the rate of rotation of the handle) an operator's changing the transmitted indication at a rate exceeding 8 knots per minute. Stops are also provided in the gear train to prevent rotating the generator more than 360 degrees. The dial is calibrated from 0-40 knots over 360 degrees with knot and 0.2 knot graduations and is viewed through a window in the case cover. The dial is of white translucent plastic with black markings and is illuminated by a type CS 5/17, 115 volt lamp mounted behind the dial. A shadow line on the back of the dial provides the indication when the dial is illuminated and a fixed bug type pointer is provided for use when the dial is not illuminated.

DUMMY LOG DISTANCE TRANSMITTER - DRWG. NO. V-40256

6. The distance transmitter, in general, consists of, a type "M" self-synchronous motor to which is attached the cam of the follow-up system, a follow-up system consisting of a reversible motor and a cam-operated set of contacts, a disc and roller assembly with a synchronous motor to supply a constant speed to the disc, a shaded-pole induction motor with speed adjusting rheostat, and a type "B" self-synchronous generator. All equipment is contained in a cast aluminum, ventilated, drip-proof case for bulkhead mounting. The self-synchronous motor positions the cam, and the contacts operated thereby cause the reversible motor to position the disc on the roller so that the rotary motion imparted to the roller by the disc is proportional to the angular position of the cam and self-synchronous motor. Since the self-synchronous motor is positioned by the speed transmitter, it follows that the speed of the roller is also proportional to the angular setting of the speed transmitter. One end of the roller shaft is attached to a sun gear in a spur gear differential, and the shaft of the self-synchronous generator, driven by the shaded pole motor, is attached to the other sun gear in the differential. The planetary gears of the differential are mounted in a cage, equipped with a

DUMMY LOG DISTANCE TRANSMITTER - DRWG. NO. V-40256 (CONTD.)

spur type ring gear, and are free to respond to any difference of speed between the sun gears when the sun gears are driven in opposite directions. Any motion of the cage, caused by differences in the speeds of the sun gears, is transmitted by the ring gear to the arm of a rheostat in the shaded-pole motor circuit. When the speeds of the sun gears are equal and opposite there will be no motion of the cage of the differential or of the rheostat arm, but when unequal, the cage will rotate and cause the rheostat arm to move in the direction required to bring the speed of the self-synchronous generator again equal and opposite to that of the roller. When the speed of the self-synchronous generator is equal and opposite to that of the roller, its speed will also be proportional to the setting of the speed transmitter as will be the speed of any self-synchronous motor connected thereto. The constants of the transmitter are such that the self-synchronous generator provides an output of 360 revolutions per simulated nautical mile of distance traveled by the ship; or 6 rpm per knot of simulated ship's speed.

METHOD OF TEST

7. The test was conducted as outlined in contract, reference (b), with modifications, reference (c), in the following general order:

- (a) Endurance Test, first part, for 50 hours - the equipment being constantly varied from zero to maximum indicated speed and back to zero at a rate of 8 knots per minute.
- (b) Accuracy Test No. 1, with voltage variations of ± 7 volts and frequency variations of ± 5 cycles in the supplies to all equipment except the synchronous motor for which only the voltage was varied.
- (c) Shock and Vibration Test.
- (d) Accuracy Test No. 2, under same conditions as (b) above.
- (e) Endurance Test, second part, for 450 hours. Under conditions as follows:
 - (1) 150 hours at $1/4$ full scale speed and at an ambient temperature of 60-80 degrees F.
 - (2) 150 hours at $1/2$ full scale speed and at an ambient temperature of 30 degrees F.
 - (3) 150 hours at $3/4$ full scale speed and at an ambient temperature of 130 degrees F.

Note: Equipment was oiled in accordance with the manufacturer's instructions after the first 150 hours of this portion of the test.

- (f) Accuracy Test No. 3, under same conditions as (b) above.
- (g) Enclosure Tests.

METHOD OF TEST (CONTD.)

(h) Dielectric and Insulation Tests.

(i) Electrical Characteristics.

8. During all tests (except portions of the endurance test, second part, when occasionally it was necessary to leave the equipment unattended) the equipment was operated with a 5 oz-in torque load applied to a self-synchronous motor, to be identified hereafter as the "loading motor", connected to the self-synchronous generator in the distance transmitter. The loading motor simulates the operation of the distance input motor in the dead reckoning analyzer and the rotation of the motor becomes the "distance output" of the dummy log distance transmitter. The loading motor was however, a regular type "M" motor and was not of the differential type understood to be used in a dead reckoning analyzer. A four pound (0.5 inch by 6 inch diameter) wheel was attached to the shaft of the loading motor to simulate the inertia load imposed by the discs in the dead reckoning analyzer.

9. The source of supply for the synchronous motor was commercial 115 volt, 60 cycles, ac, which was accepted as having average variations in frequency considerably less than the 0.1% of 60 cycles, required.

10. The test was concluded with a general inspection of the equipment pertaining to design and workmanship and a check of the equipment against the manufacturer's drawings.

11. Due to mechanical failures in the component parts of the distance transmitter when subjected to the shock test, more than one shock test was performed and additional accuracy tests were made each time the equipment was repaired and adjusted. All repairs and adjustments required were performed by a representative of the manufacturer.

RESULTS OF TESTS

12. The results of the tests conducted are as follows:

Requirements (from Contract and Modifications unless otherwise specified.)

Test Values

Accuracy of Speed Indications:
Allowable error \pm 0.4 knots.

Complied.
See Tables (1), (3), (5), (7), and (8).

Accuracy of "Distance Output":
Allowable error \pm 1.2 rpm.

* 51 test points of 159 tested showed an error in excess of requirement. See Tables (2), (4), (6), (7), and (8), and comments, paragraph 13, and 14.

Shock and Vibration of Speed Transmitter: Para. F-2i of ref. (d).

Complied.
See comments, paragraph 15.

RESULTS OF TESTS (CONTD.)

Requirements (from Contract and Modifications unless otherwise specified.)

Test Values

Shock and Vibration of Distance Transmitter: Para. F-2i of ref. (d).	* Various component parts became deranged and the unit failed to maintain the required accuracy. See comments, para. 16, 17, and 18.
Endurance - Speed Transmitter.	Complied. See comments, para. 19.
Endurance - Distance Transmitter.	* See comments, para. 20.
Dielectric and Insulation: Para. F-2L of ref. (d).	Complied.
Enclosure - Speed Transmitter: Watertight - Degree C - Para. D-1k of ref. (e).	* Leaked 442 cc around cover gasket and approx. 1 cc leaked around hand crank shaft.
Enclosure - Distance Transmitter: Dripproof - para. D-1g. of ref. (e).	Complied.
Power Consumption: Not specified.	Total system - 106 watts, 4.25 amps. at 115 volts, 60 cycles, ac.
Operation - Speed Transmitter: Rate of speed change not to exceed 8 knots per minute.	* Rate of speed change can be as high as 52 knots per minute.
Painting of Enclosures: Para. C-4f. of ref. (d).	* No paint on either enclosure.
Wiring:	Wiring between component parts at times prevented the proper operation of the constant speed disc carriage. This factor was corrected each time that it occurred and is not reflected in the test results.

Note: * -- Denotes Non-compliance.

COMMENTS ON RESULTS OF TESTS

13. From the results of the "distance output" accuracy tests it will be noted that the errors are predominately negative and that the magnitudes of the few positive errors obtained are relatively small. It should be possible to adjust the equipment in a manner that would reduce the magnitude of the maximum negative error while increasing the magnitude of the maximum positive error. Using + 0.5 rpm as the maximum positive error obtained and - 2.8 rpm as the maximum negative error, a theoretical accuracy of ± 1.65 rpm should be attainable. This

COMMENTS ON RESULTS OF TESTS (CONTD.)

would, however, disregard the three (3) points in Accuracy Test No. 3, see Table No. 6, where at a speed setting of 39 knots the error exceeded - 2.8rpm. These particular errors occurred only at this point and did not repeat in any other accuracy test. Such an adjustment as described was attempted during this test, but the condition of the equipment precluded any such fine adjustments. In any event, with the best adjustment possible for this particular equipment the accuracy could not satisfy the conditions of the requirements, namely, ± 1.2 rpm.

14. After considerable operation it was noted that rings were appearing on the constant speed disc and that these rings coincided with roller positions for the particular speed settings at which the accuracy tests were conducted. The disc had become quite rough in these rings but the rings did not appear to form grooves. Another accuracy test was conducted, using speed settings which positioned the roller between the rings, to determine (by comparison) the effect of the rings on the accuracy of the "distance output". The accuracy, see Table No. 7, was essentially the same as in the previous test and it was concluded that the presence of the rings had no effect on the accuracy.

15. During the shock test of the speed transmitter, a section of the dial, cracked in one place when received, broke out on the 18th blow. This fault cannot be attributed directly to the shock test. The dial lamp failed completely on the 18th blow and, after the test, the filament was found to be shorted. A new lamp functioned properly when inserted in the socket, following the test. One of the dowel pins in the chassis became free and was found on the bottom of the case, after the test.

16. After the shock test on the distance transmitter, certain components had become deranged and the operation was so affected that continuance of the test was not justified. The defects noted, were as follows:

- (a) The constant speed disc carriage had loosened - the nut on the bottom of the carriage that is driven by the lead screw was completely loose, permitting the carriage to move freely. On this particular unit, this nut is of the split type, fastened together by two screws and not pinned to the carriage.
- (b) The rheostat arm passed the stops at both ends of travel - the gear on the rheostat arm shaft was fastened by only one (1) allen screw, which had loosened.
- (c) The constant speed disc shaft was bent out of alignment - this was only a slight amount and the spring takeup on the disc shaft was sufficient to maintain pressure on the roller and prevent slipping.
- (d) The contacts for the control of the reversible motor no longer centered - this prevented the proper positioning of the disc carriage.
- (e) Additional friction had been added somewhere in the gear train from the reversible motor to the lead screw - this also prevented

COMMENTS ON RESULTS OF TESTS (CONTD.)

the proper positioning of the disc carriage and it was necessary to jar the case of the unit each time a new setting was made to allow the motor to complete the positioning action.

- (f) The loading motor had an oscillatory motion superimposed upon the regular rotation. This erratic action was also observed in the type "B" generator, in the distance transmitter and was apparent in the operation of the shaded-pole motor and in the differential.

17. The major defects in the distance transmitter were corrected and the necessary adjustments made, by a manufacturer's representative, and a second shock test was conducted. After this shock test the head of the lead screw that positions the constant speed disc carriage was found to be loose in the frame and the carriage could move freely, as much as 0.012 inches. This is a very material amount when considering that the carriage moves only 1.25 inches to cover the entire range from 0 to 40 knots, or 0.031 inches per knot. The accuracy of the "distance output" was found to be very poor and precluded the continuance of the tests.

18. Corrections and adjustments were again made by a manufacturer's representative, but further shock tests were deferred until after the accuracy and endurance tests. In the final shock test, which was stopped after the 10th blow, the defects noted were as follows:

- (a) The constant speed disc shaft was bent further out of alignment on the first blow - subsequent blows corrected part of the misalignment.
- (b) The constant speed disc carriage was again loosened. The free movement was now as much as 0.010 inches.
- (c) The screw pin holding the gear on the self-synchronous generator shaft was broken and the gear became loose.
- (d) The synchronous motor would stall and would not start again. Inspection after the test showed that one wire to the condenser on the motor had completely broken free. When this wire was resoldered the motor functioned normally.

19. During the endurance test, first part, the speed transmitter stalled after approximately 25 hours of operation and the hand crank could not be turned in either direction. Inspection of the equipment showed that shaft, pc. 27, which couples to the hand crank shaft, was bound in its bearing on bearing bracket, pc. 78, due to lack of oil. No oil hole had been provided in the bracket bearing for lubricating this shaft. The shaft was replaced and an oil hole was drilled in the bracket bearing, by a manufacturer's representative, after which the test was repeated with no subsequent failures.

COMMENTS ON RESULTS OF TESTS (CONTD.)

20. During the very last portion of the endurance test the loading motor would stall, at times, and it was necessary to spin the wheel attached to the motor before the motor would again start and run. After removal of the equipment from the temperature cabinet and while the distance transmitter was operating, it was found that the differential ring gear and the rheostat arm were oscillating continuously and at times the oscillation became very violent. During the violent periods of oscillation the roller would commence slipping and eventually would stop completely with a corresponding stopping of the loading motor. When the wheel attached to the loading motor was given a spin, the equipment would start and continue to run until the stalling action repeated. A reddish deposit, resembling iron rust, had formed on the constant speed disc where the roller had been operating while the equipment was in the temperature cabinet. This rust with the oil on the disc had formed a pasty deposit and, where the roller had operated, grooves had formed in the deposit. Also, in spite of its apparent free oscillation, the rheostat mechanism required a greater turning force than was required before the equipment was placed in the temperature cabinet. After an inspection of the equipment by a manufacturer's representative, the disc was cleaned and the rheostat mechanism was oiled, following which the stalling ceased but the oscillation persisted. The operation was now normal enough to permit the final accuracy test to be made. However, it was quite difficult to apply a uniform load to the loading motor as, at slow speeds, the loading motor would continuously stall and overspeed (as the rheostat arm oscillated) and at the higher speeds the rate of rotation was very non-uniform.

21. After the final accuracy test, a study of the equipment was made and the observations with some (probable) explanations are listed as follows:

(a) With the equipment operating normally,

- (1) The frequency of the oscillatory motion, which appears in the operation of the ring gear of the differential, the rheostat arm, the shaded-pole motor, the type "B" generator and the loading motor, varies with the speed and increases as the speed increases.
- (2) The amplitude of the oscillation is dependent upon the amount of friction in the rheostat mechanism and increases as the friction is decreased.
- (3) With the rheostat arm held firmly in a position corresponding to normal position for a given speed setting, the oscillation, while not as pronounced, still appears in the operation of the shaded-pole motor, the type "B" generator and the loading motor.
- (4) When the rotor of the loading motor was stopped suddenly and firmly held, the balance of the equipment would continue to operate. The operation was, however, very erratic, due to the field reactions in the loading motor being reflected back to the generator. This demonstrated that there is sufficient torque developed in the mechanism driving the transmitter to cause the rotor of the loading motor to slip 180 degrees or more with relation to the rotating field.

COMMENTS ON RESULTS OF TESTS (CONTD.)

- (b) With the rheostat arm disengaged from the ring gear of the differential and operated manually,
- (1) When the rheostat arm was brought to a position corresponding to normal for the speed setting, the speed of the type "B" generator greatly exceeded the speed of the roller and the ring gear rotated very rapidly in the same direction of rotation as the type "B" generator. The speed of the loading motor, which should normally be approximately 180 rpm for the particular setting, was 370 rpm, when measured with a hand tachometer. Some oscillation could be detected. It is apparent then that for a normal setting of the rheostat the shaded-pole motor develops sufficient torque to rotate the type "B" generator at a much higher rate of speed than that of the roller. The oscillation noted could be normal hunting in the loading motor reflected back to the type "B" generator.
 - (2) When the ring gear was stopped and firmly held, the speed of the loading motor dropped to 172 rpm, which is approximately correct for normal operation. Some oscillation still persisted. It is therefore apparent that the disc and roller not only serve to supply the regulating speed to the differential, but also at times serve to apply an additional load to the shaded-pole motor and thereby cause the slip of the motor to increase.
 - (3) When the synchronous motor was stopped, with the ring gear free, the speed of the loading motor became 230 rpm. The oscillation was then very pronounced. Since the sun gear on the roller shaft was then stationary, the increase in friction in the differential between the stationary sun gear and the rotating planet gears, could supply sufficient increased load to the shaded-pole motor to cause the difference between the speed noted here and that noted in (1) above.

22. In the design of this equipment, it was endeavored to obtain an arrangement by which the speed of the type "B" generator automatically could be matched with that of the roller (by means of a shaded-pole induction motor with an adjustable rheostat, mechanically positioned by the cage on the differential) so that the speeds of the two components were always equal and opposite. It is desirable in equipment of this type to have an auxiliary source of mechanical power driving the type "B" generator that will not only exactly match the speed of the roller from 0 to 240 rpm, but also have torque output sufficient at all speeds to supply all the torque to the type "B" generator. Any motion of the ring gear to adjust the rheostat in the shaded-pole motor circuit, is dependent upon a difference in speed existing between the two sun gears of the differential, that is, a difference of speed between the roller and the type "B" generator. Since movement of the ring gear can occur only from torque transmitted through the differential by one or the other of the sun gears, and since motion of the ring gear is resisted by rheostat friction, there will be considerable torque transmitted through the

COMMENTS ON RESULTS OF TESTS (CONTD.)

differential before a difference in speed (causing a change of ring gear and differential position) is possible. The maximum amount of torque transmitted through the differential, in either direction, will depend upon the amount of friction retarding the motion of the ring gear, and in this case, will be the torque necessary to overcome the "break away" friction in the rheostat.

23. Providing the shaded-pole induction motor with an adjustable series resistor does not produce a true speed regulating arrangement, but rather a torque regulation with the torque being varied as the voltage is varied and the output speed depending upon the load attached. If the resistance in the motor circuit at a given time is too low, the torque of the shaded-pole motor is not only great enough to supply the load, but will also attempt to accelerate the type "B" generator and supply a torque through the differential, during the brief period when the ring gear is stationary, great enough to overcome the torque of the roller and tend to drive the roller at an overspeed. When the torque transmitted through the differential has reached a value necessary to overcome the friction restraining the ring gear, it will be caused to move in the same direction of rotation as that of the type "B" generator and the rheostat arm will be moved toward a point of greater resistance. The torque of the motor will decrease as the resistance is increased, but the speed of the motor cannot decrease instantly due to the inertia of the rotating system, and as a result, the rheostat arm will overtravel. The amount of overtravel will depend upon the inertia of the rotating system, the play in the gears of the differential, the friction in the differential, the friction in the rheostat, and, possibly, the play in the gear train of the synchronous motor. If the friction is relatively large, a greater torque will be required to initiate the ring gear motion, but since the torque of the motor decreases instantly with the increased resistance, the energy available to move the ring gear must come from the rotating system and the available energy will be dissipated more quickly if the friction is high. When the rheostat is stationary in its new (overtravel, high resistance) position, the torque of the motor will not be sufficient to supply the load, and the disc and roller must supply part of the torque, which part cannot exceed the amount fixed by the "break away" friction of the rheostat. If the disc and roller cannot supply the deficiency in torque necessary to drive the type "B" generator at the speed of the roller, without exceeding the torque value that will cause the ring gear to rotate, the ring gear will rotate in the same direction as the roller, and thus move the rheostat arm to decrease the resistance in the motor circuit. Here again, if the amount of friction is relatively large, a greater torque will be required to initiate the ring gear motion, but the distance the ring gear can move will be lessened due to the amount of friction. With the rheostat arm stationary in the new position, the initial condition described above will again be established and the cycle will be repeated. An oscillatory motion is thereby set up in the type "B" generator superimposed upon its normal rotation, and the oscillation will be transmitted directly to the loading motor. The frequency of this oscillation will vary with the speed and will increase as the speed is increased.

COMMENTS ON RESULTS OF TESTS (CONTD.)

24. In any system where a self-synchronous generator is connected to a self-synchronous motor, whether for continuous rotation or for positioning, any movement of the generator is opposed entirely by the inertia of the rotor in the motor plus the inertia of any load attached, and by bearing friction. The angular displacement between the rotor in the generator and the rotor in the motor, when the rotor in the generator is accelerated, will depend upon these factors, and an oscillatory motion will be set up in the movement of the rotor in the motor as the rotor hunts for realignment with the rotor in the generator. The amplitude of this oscillation will depend largely upon the inertia of the rotating system and will increase as the inertia is increased. When an angular displacement exists between the rotors of the generator and motor, the motor will become, temporarily, a generator and attempt to drive the generator as a motor. If the rotor in the generator is not positively held, any oscillatory motion of the rotor of the motor will be reflected back to the rotor in the generator, which will oscillate in the same manner.

25. In the system driven by the distance transmitter, the type "B" generator is not positively held and a relatively high inertia load is attached to the loading motor. When the type "B" generator accelerates or decelerates an oscillatory motion will be set up in the regular rotation of the loading motor, which will be amplified by the additional inertia load. This oscillatory motion will be reflected back to the generator, and the shaded-pole motor. Also, if the movement is greater than that permitted by backlash in the gears, the rheostat arm will move correspondingly. If the friction in the rheostat mechanism is high, the resulting steadying of the ring gear will reflect the oscillation to the roller and a more rigid coupling will result, if the roller does not slip on the disc. The more rigid coupling will in turn tend to decrease the amplitude of the oscillation.

26. It therefore becomes apparent that, there are two contributing factors in the initiating and maintaining of the oscillatory motion in the distance transmitter mechanism. These factors are, first, the hunting effect of the shaded-pole motor in its attempt to match the speed of the type "B" generator with that of the roller, and, second, the natural oscillation that is set up in a self-synchronous generator and motor circuit when the generator is not positively held. Either one of these factors can initiate the oscillatory action and, once started, the two factors may assist each other in the maintaining of the action.

27. From either of the oscillatory actions described, it will be noted that the roller is continuously subjected to a torque which alternately attempts to cause the roller to run faster or slower than the speed imparted by the disc. This results in an abrasive action between the roller and the disc if there is any slippage, and would produce the roughened rings that developed on the disc when the equipment was operated at a particular speed for a long period of time. Also, the rust on the disc, observed after the endurance test, could have resulted from oxidation of fine particles of metal removed from the disc and roller by the abrasive action.

COMMENTS ON RESULTS OF TESTS (CONTD.)

28. Since the frequencies of the oscillatory actions observed are not the same, there will only be certain periods when the two actions are additive. When additive, the resulting oscillatory action should become very violent and, when subtractive, the actions should tend to neutralize to produce a more steady state. Such action was observed in this equipment, while operating.

29. The accuracy of the "distance output" may also be affected by the oscillatory motion in the system. The total number of revolutions the loading motor will turn in a given interval of time will depend upon the average of the speeds imparted to the motor by the type "B" generator. Since the type "B" generator is continuously being accelerated or decelerated the average speed may not be the mean of the maximum and minimum speeds, but could be higher or lower depending upon the ability of the shaded-pole motor and its controlling means to adjust the speed of the generator.

30. Some oscillation at the ring gear is inherent in most differentials when run with a "free" ring gear. However, the friction in the rheostat mechanism in this application should supply sufficient damping to make this negligible after other necessary modifications are made.

CONCLUSIONS

31. From the tests conducted on the laboratory models of the Friez Type DL-40 Dummy Log Equipment, the following may be concluded:

- (a) Since the units of the equipment are laboratory models, some of the defects noted may readily be corrected when the equipment is on a production basis, namely,

Speed Transmitter

- (1) The leak around the shaft of the hand crank.
- (2) The leak around the cover gasket.
- (3) The fracture of the dial.
- (4) Painting of enclosure.

Distance Transmitter

- (5) The derangement of the contacts in the reversible motor circuit.
- (6) The increased friction in the reversible motor gear train.
- (7) The loosening of the nut on the bottom of the constant speed disc carriage. It is understood that this nut, on production equipment, is to be cast integral with the frame of the carriage.
- (8) The loosening of the lead screw head in the frame, permitting end-play.
- (9) Bending of the disc shaft out of alignment.
- (10) Painting of enclosure.

- (b) However, it is felt that in some instances design changes should be made to better the overall operation of the equipment, namely,

Speed Transmitter

- (1) Better means of relamping.
- (2) Change air-vane damping device to limit the rate of speed change to 8 knots per minute. It is possible to rotate the hand crank at a rate that is high enough to cause the roller in the contact mechanism to pass over the end of the heart-shaped cam. This reverses the positioning motor and causes the disc to be positioned incorrectly on the roller, producing erroneous "distance outputs".
- (3) Provide means of preventing the hand crank from being turned while the system is not energized. This displaces the rotor in the generator of the speed transmitter without the corresponding action of rotor in the self-synchronous motor in the distance transmitter. This displacement can be great enough that, when the system is energized, the motor will rotate sufficiently to permit the roller to pass over the end of the heart-shaped cam. Erroneous "distance outputs" are then produced, as was described above.

Distance Transmitter

- (4) Wiring between component parts should be better placed to prevent interference with operation.
- (5) Add skirts to bottom vent ports in case cover.

CONCLUSIONS (CONTD.)

- (6) Add screens in top vents to prevent the entry of vermin.
 - (7) Provide separable terminal strips to facilitate inspection and oiling which must be done very frequently.
- (c) Due to the many probable differences between the laboratory models and the production equipment a check of the equipment against the manufacturer's drawings has been deferred until the anticipated return for test following modifications.

TABLE NO. 1

ACCURACY TEST No. 1 - SPEED TRANSMITTER

CONDUCTED BEFORE ALL OTHER TESTS

Speed Transmitter Indication	SPEED INDICATION					
	108 V - 55 Cycle		115 V - 60 Cycle		122 V - 65 Cycle	
	Indicated	Error	Indicated	Error	Indicated	Error
Knots	Knots	Knots	Knots	Knots	Knots	Knots
0	0	0	0	0	0	0
2	1.97	-0.03	1.97	-0.03	1.97	-0.03
4	3.92	-0.08	3.92	-0.08	3.92	-0.08
6	5.92	-0.08	5.92	-0.08	5.92	-0.08
9	8.92	-0.08	8.92	-0.08	8.92	-0.08
16	16.01	+0.01	16.01	+0.01	16.01	+0.01
20	20.03	+0.03	20.02	+0.02	20.02	+0.02
25	25.02	+0.02	25.00	-0.00	25.02	+0.02
30	29.97	-0.03	29.98	-0.02	29.97	-0.03
35	34.93	-0.07	34.93	-0.07	34.93	-0.07
39	38.93	-0.07	38.92	-0.08	38.93	-0.07
40	39.91	-0.09	39.91	-0.09	39.91	-0.09

Note: Maximum Allowable Error $\pm 1\%$ of Full Scale = ± 0.4 Knots.

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TABLE NO. 2

ACCURACY TEST No. 1 - DISTANCE TRANSMITTER

CONDUCTED BEFORE ALL OTHER TESTS
 TORQUE LOAD ON DISTANCE OUTPUT SYNCRO. - 5 oz.-ins.

Speed Transmitter Indication	Required	DISTANCE OUTPUT					
		108 V - 55 Cycle		115 V - 60 Cycle		122 V - 65 Cycle	
Knots	rpm	Average rpm	Error rpm	Average rpm	Error rpm	Average rpm	Error rpm
0	0	0	0	0	0	0	0
2	12	11.55	-0.45	12.0	0.0	11.25	-0.75
4	24	23.40	-0.60	24.4	+0.4	23.05	-0.95
6	36	35.3	-0.7	36.5	+0.5	35.1	-0.9
9	54	53.1	-0.9	54.4	+0.4	53.2	-0.8
16	96	95.4	-0.6	96.1	+0.1	95.4	-0.6
20	120	119.3	-0.7	119.7	-0.3	119.2	-0.8
25	150	149.1	-0.9	148.8	-1.2	149.2	-0.8
30	180	178.8	-1.2	178.8	-1.2	178.8	-1.2
35	210	208.4	-1.6	208.8	-1.2	208.5	-1.5
39	234	232.2	-1.8	232.4	-1.6	231.8	-2.2
40	240	*...	...	*...	...	*...	...

Note: Maximum Allowable Error - \pm 1.2 rpm.

* - Upper Limit Switch prevents proper operation at this Setting.

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TABLE NO. 3

ACCURACY TEST NO. 2 - SPEED TRANSMITTER

CONDUCTED AFTER SHOCK TEST AND ADJUSTMENTS ON
DISTANCE TRANSMITTER

Speed Transmitter Indication	SPEED INDICATION							
	UP SCALE						DOWN SCALE	
	108 V - 55 Cycle		115 V - 60 Cycle		122 V - 65 Cycle		115 V - 60 Cycle	
	Indicated	Error	Indicated	Error	Indicated	Error	Indicated	Error
Knots	Knots	Knots	Knots	Knots	Knots	Knots	Knots	Knots
0	0	0	0	0	0	0	0	0
2	2.01	+0.01	2.01	+0.01	2.01	+0.01	1.99	-0.01
4	3.98	-0.02	3.98	-0.02	3.98	-0.02	4.01	+0.01
6	5.97	-0.03	5.97	-0.03	5.97	-0.03	5.98	-0.02
9	8.97	-0.03	8.97	-0.03	8.97	-0.03	8.98	-0.02
16	15.99	-0.01	15.99	-0.01	15.99	-0.01	16.04	+0.04
20	20.03	+0.03	20.02	+0.02	20.03	+0.03	20.08	+0.08
25	25.00	0.00	25.00	0.00	25.00	0.00	25.03	+0.03
30	29.97	-0.03	29.97	-0.03	29.97	-0.03	29.96	-0.04
35	34.96	-0.04	34.96	-0.04	34.96	-0.04	35.02	+0.02
39	38.96	-0.04	38.96	-0.04	38.96	-0.04	38.98	-0.02
40	39.92	-0.08	39.92	-0.08	39.92	-0.08	39.92	-0.08

Note: Maximum allowable error $\pm 1\%$ of full scale = ± 0.4 Knots.

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TABLE NO. 4

ACCURACY TEST No. 2 - DISTANCE TRANSMITTER

CONDUCTED AFTER SHOCK TEST AND ADJUSTMENTS
TORQUE LOAD ON DISTANCE OUTPUT SYNCRO - 5 oz-ins.

Speed Transmitter Indication	DISTANCE OUTPUT								
	Required	UP SCALE				DOWN SCALE			
		108 V - 55 Cycle	115 V - 60 Cycle	122 V - 65 Cycle	115 V - 60 Cycle	Average	Error	Average	Error
Knots	rpm	Average rpm	Error rpm	Average rpm	Error rpm	Average rpm	Error rpm	Average rpm	Error rpm
0	0	0	0	0	0	0	0	0	0
2	12	12.2	+0.2	12.3	+0.3	12.1	+0.1	11.0	-1.0
4	24	24.2	+0.2	24.1	+0.1	24.1	+0.1	23.2	-0.8
6	36	35.5	-0.5	35.6	-0.4	35.5	-0.5	35.4	-0.6
9	54	53.2	-0.8	53.2	-0.8	53.1	-0.9	53.3	-0.7
16	96	95.3	-0.7	95.6	-0.4	95.6	-0.4	95.5	-0.5
20	120	119.2	-0.8	119.2	-0.8	119.0	-1.0	118.7	-1.3
25	150	149.0	-1.0	149.2	-0.8	149.2	-0.8	148.8	-1.2
30	180	178.6	-1.4	178.6	-1.4	178.6	-1.4	178.6	-1.4
35	210	209.2	-0.8	209.4	-0.6	209.2	-0.8	208.4	-1.6
39	234	232.0	-2.0	232.8	-1.2	232.0	-2.0	232.4	-1.6
40	240	*...	...	*...	...	*...	...	*...	...

Note: Maximum allowable error - ± 1.2 rpm.

* -- Upper Limit Switch prevents proper operation at this setting.

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TABLE NO. 5

ACCURACY TEST No. 3 - SPEED TRANSMITTER

CONDUCTED AFTER SHOCK AND VIBRATION TEST

Speed Transmitter Indication Knots	SPEED INDICATION							
	UP SCALE						DOWN SCALE	
	108 V - 55 Cycle		115 V - 60 Cycle		122 V - 65 Cycle		115 V - 60 Cycle	
	Indicated Knots	Error Knots	Indicated Knots	Error Knots	Indicated Knots	Error Knots	Indicated Knots	Error Knots
0	0	0	0	0	0	0	0	0
2	1.97	-0.03	1.97	-0.03	1.97	-0.03	1.98	-0.02
4	3.91	-0.09	3.91	-0.09	3.91	-0.09	3.98	-0.02
6	5.91	-0.09	5.91	-0.09	5.91	-0.09	5.98	-0.02
9	8.89	-0.11	8.89	-0.11	8.89	-0.11	8.96	-0.04
16	15.87	-0.13	15.87	-0.13	15.87	-0.13	15.97	-0.03
20	19.91	-0.09	19.89	-0.11	19.91	-0.09	19.99	-0.01
25	24.98	-0.02	24.98	-0.02	24.98	-0.02	24.96	-0.04
30	29.86	-0.14	29.86	-0.14	29.86	-0.14	29.90	-0.10
35	34.87	-0.13	34.87	-0.13	34.87	-0.13	34.97	-0.03
39	38.88	-0.12	38.88	-0.12	38.88	-0.12	38.97	-0.03
40	39.89	-0.11	39.89	-0.11	39.89	-0.11	39.89	-0.11

Note: Maximum allowable error $\pm 1\%$ of full scale = ± 0.4 Knots.

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TABLE NO. 6

ACCURACY TEST No. 3 - DISTANCE TRANSMITTER

CONDUCTED AFTER SECOND SHOCK AND VIBRATION TEST AND ADJUSTMENTS
 TORQUE LOAD ON DISTANCE OUTPUT SYNCRO - 5 oz-ins.

Speed Transmitter Indication	Required	DISTANCE OUTPUT							
		UP SCALE				DOWN SCALE			
		108 V - 55 Cycle		115 V - 60 Cycle		122 V - 65 Cycle		115 V - 60 Cycle	
Knots	rpm	Average rpm	Error rpm	Average rpm	Error rpm	Average rpm	Error rpm	Average rpm	Error rpm
0	0	0	0	0	0	0	0	0	0
2	12	11.4	-0.6	11.6	-0.4	11.5	-0.5	11.4	-0.6
4	24	23.2	-0.8	23.1	-0.9	23.2	-0.8	23.3	-0.7
6	36	35.6	-0.4	35.6	-0.4	35.5	-0.5	35.5	-0.5
9	54	53.4	-0.6	53.4	-0.6	53.4	-0.6	53.0	-1.0
16	96	95.0	-1.0	94.9	-1.1	95.0	-1.0	95.3	-0.7
20	120	118.2	-1.8	118.4	-1.6	118.2	-1.8	118.3	-1.7
25	150	147.8	-2.2	147.8	-2.2	147.8	-2.2	148.5	-1.5
30	180	177.4	-2.6	177.3	-2.7	177.4	-2.6	177.4	-2.6
35	210	207.5	-2.5	207.3	-2.7	207.3	-2.7	208.0	-2.0
39	234	231.0	-3.0	230.9	-3.1	230.8	-3.2	231.4	-2.6
40	240	*...	...	*...	...	*...	...	*...	...

Notes: Maximum Allowable Error - ± 1.2 rpm.

* -- Upper Limit Switch prevents proper operation at this setting.

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TABLE NO. 7

ACCURACY TEST No. 3 - SPEED AND DISTANCE TRANSMITTERS

CONDUCTED AFTER SHOCK AND VIBRATION TESTS AND ADJUSTMENTS
TO DISTANCE TRANSMITTER

TORQUE LOAD ON DISTANCE OUTPUT SYNCRO - 5 oz-ins.

Supply - 115 Volts, 60 Cycle

Speed Transmitter Indication Knots	SPEED INDICATION				DISTANCE OUTPUT				
	UP SCALE		DOWN SCALE		Required rpm	UP SCALE		DOWN SCALE	
	Indicated Knots	Error Knots	Indicated Knots	Error Knots		Average rpm	Error rpm	Average rpm	Error rpm
0	0	0	0	0	0	0	0	0	0
5	4.91	-0.09	4.96	-0.04	30	29.0	-1.0	29.4	-0.6
12	11.87	-0.13	11.97	-0.03	72	71.0	-1.0	71.6	-0.4
18	17.90	-0.10	17.99	-0.01	108	106.4	-1.6	107.2	-0.8
22	21.89	-0.11	21.97	-0.03	132	130.4	-1.6	130.8	-1.2
28	27.87	-0.13	27.96	-0.04	168	165.8	-2.2	166.2	-1.8
32	31.87	-0.13	31.96	-0.04	192	189.4	-2.6	189.8	-2.2
38	37.90	-0.10	37.99	-0.01	228	225.4	-2.6	226.0	-2.0
40	39.89	-0.11	39.89	-0.11	240	*...*	...*	*...*	...*

Note: Maximum allowable error-Speed $\pm 1\%$ full scale ± 0.4 Knots
Distance- ± 1.2 rpm.

* -- Upper limit switch prevents proper operation at this setting.

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TABLE NO. 8

ACCURACY TEST No. 4 - SPEED AND DISTANCE TRANSMITTERS

CONDUCTED AFTER ENDURANCE TEST

TORQUE LOAD ON DISTANCE OUTPUT SYNCRO - 5 oz-ins.

Supply - 115 Volts, 60 Cycle.

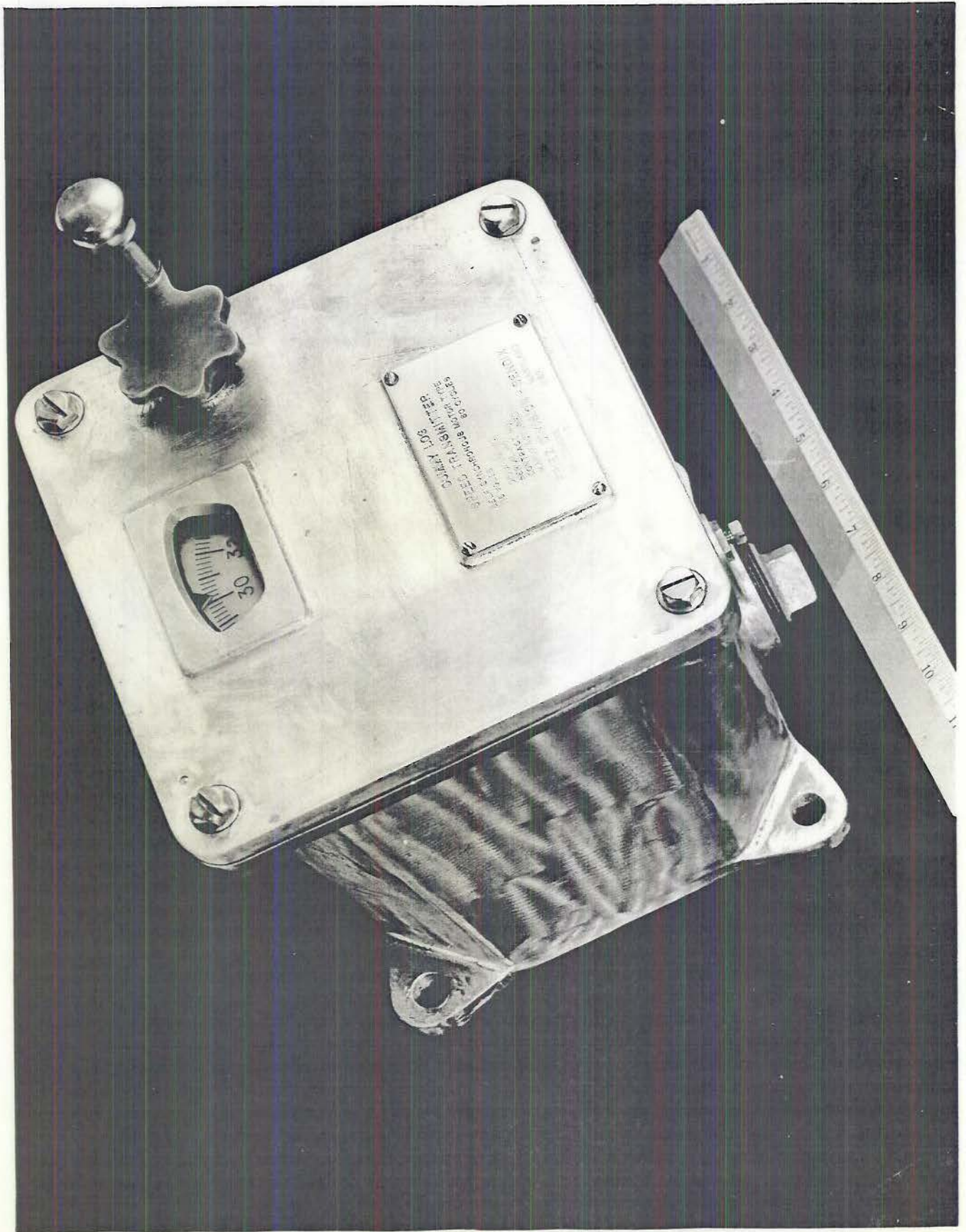
Speed Transmitter Indication Knots	SPEED INDICATION				Required rpm	DISTANCE OUTPUT			
	UP SCALE		DOWN SCALE			UP SCALE		DOWN SCALE	
	Indicated Knots	Error Knots	Indicated Knots	Error Knots		Average rpm	Error rpm	Average rpm	Error rpm
0	0	0	0	0	0	0	0	0	0
2	1.96	-0.04	1.98	-0.02	12	** 10.4	-1.6	** 12.5	+0.5
4	3.91	-0.09	4.00	0.00	24	** 23.4	-0.6	** 23.9	-0.1
6	5.90	-0.10	5.97	-0.03	36	** 35.2	-0.8	** 36.2	+0.2
9	8.91	-0.09	8.96	-0.04	54	** 53.7	-0.3	54.0	0.0
16	15.91	-0.09	15.99	-0.01	96	95.2	-0.8	95.6	-0.4
20	19.91	-0.09	20.00	0.00	120	117.7	-2.3	120.0	0.0
25	24.90	-0.10	24.97	-0.03	150	147.8	-2.2	148.5	-1.5
30	29.86	-0.14	29.91	-0.09	180	177.8	-2.2	178.9	-1.1
35	34.88	-0.12	34.96	-0.04	210	207.9	-2.1	208.5	-1.5
39	38.91	-0.09	38.98	-0.02	234	231.2	-2.8	231.3	-2.7
40	39.91	-0.09	39.91	-0.09	240	*...	...	*...	...

Note: Maximum allowable error - Speed - $\pm 1\%$ of full scale - ± 0.4 Knots.
Distance - ± 1.2 rpm.

* -- Upper Limit Switch prevents proper operation at this setting.

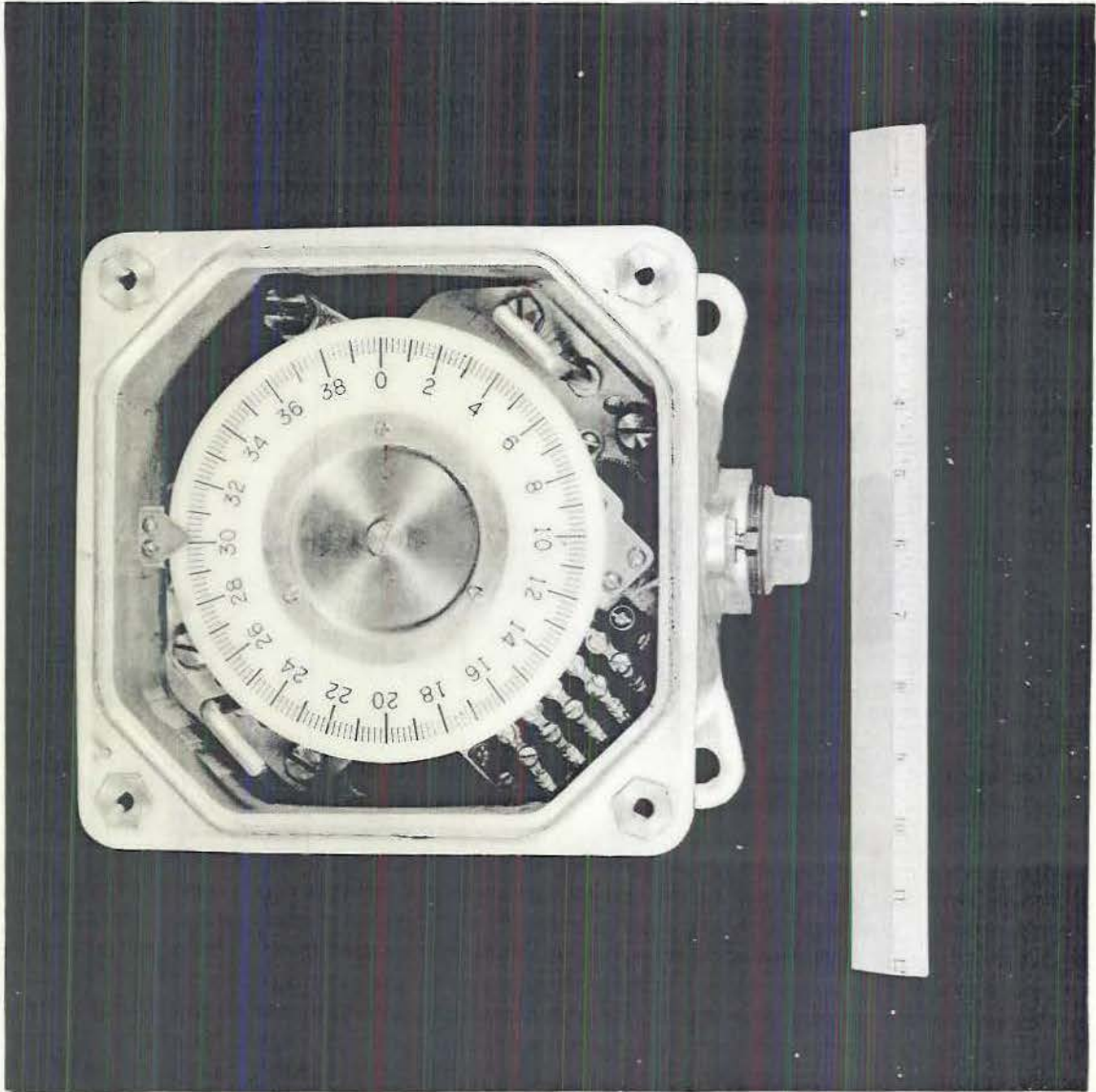
** -- Operation unstable and readings not reliable.

DECLASSIFIED



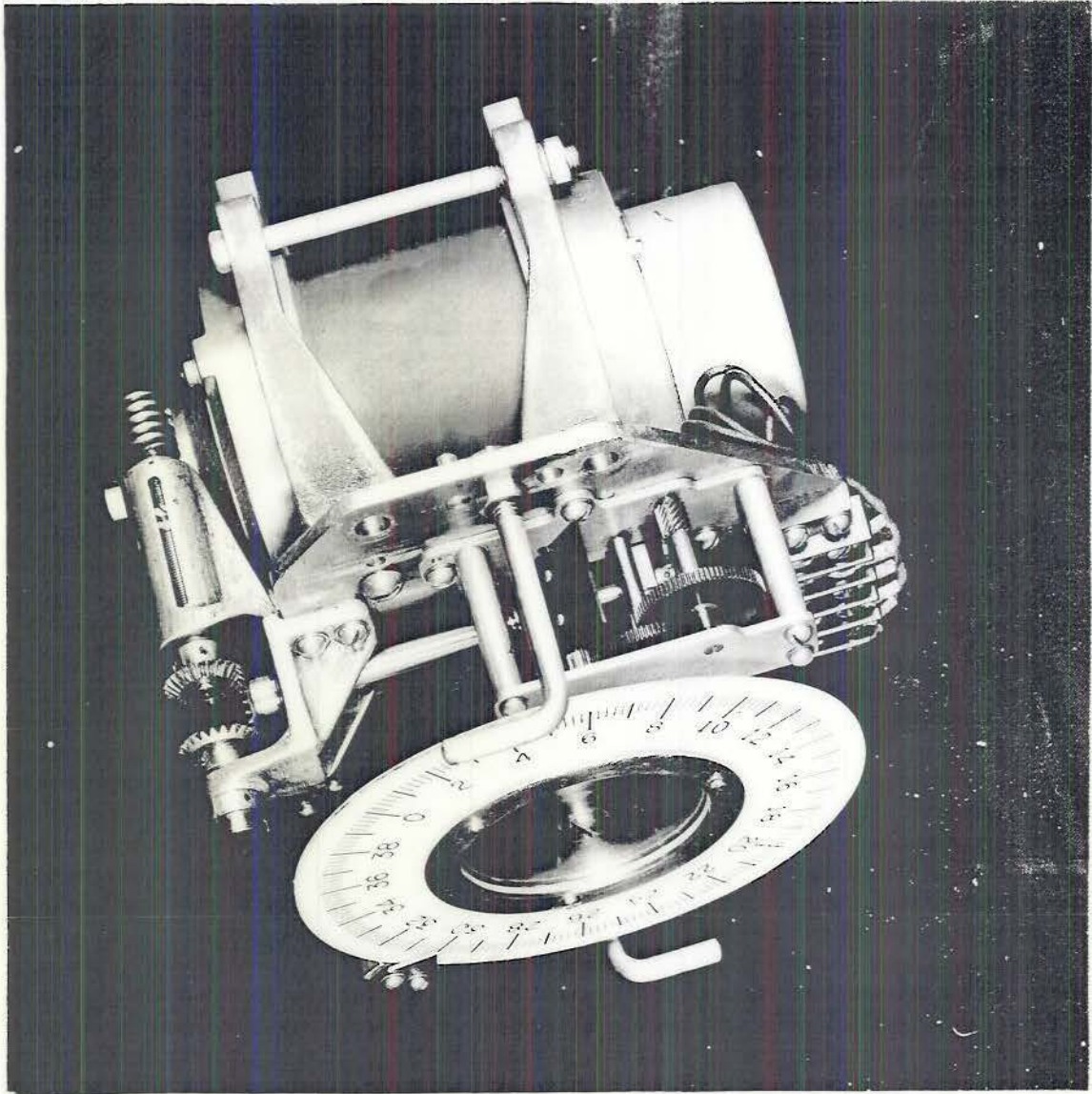
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PLATE I



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PLATE 2



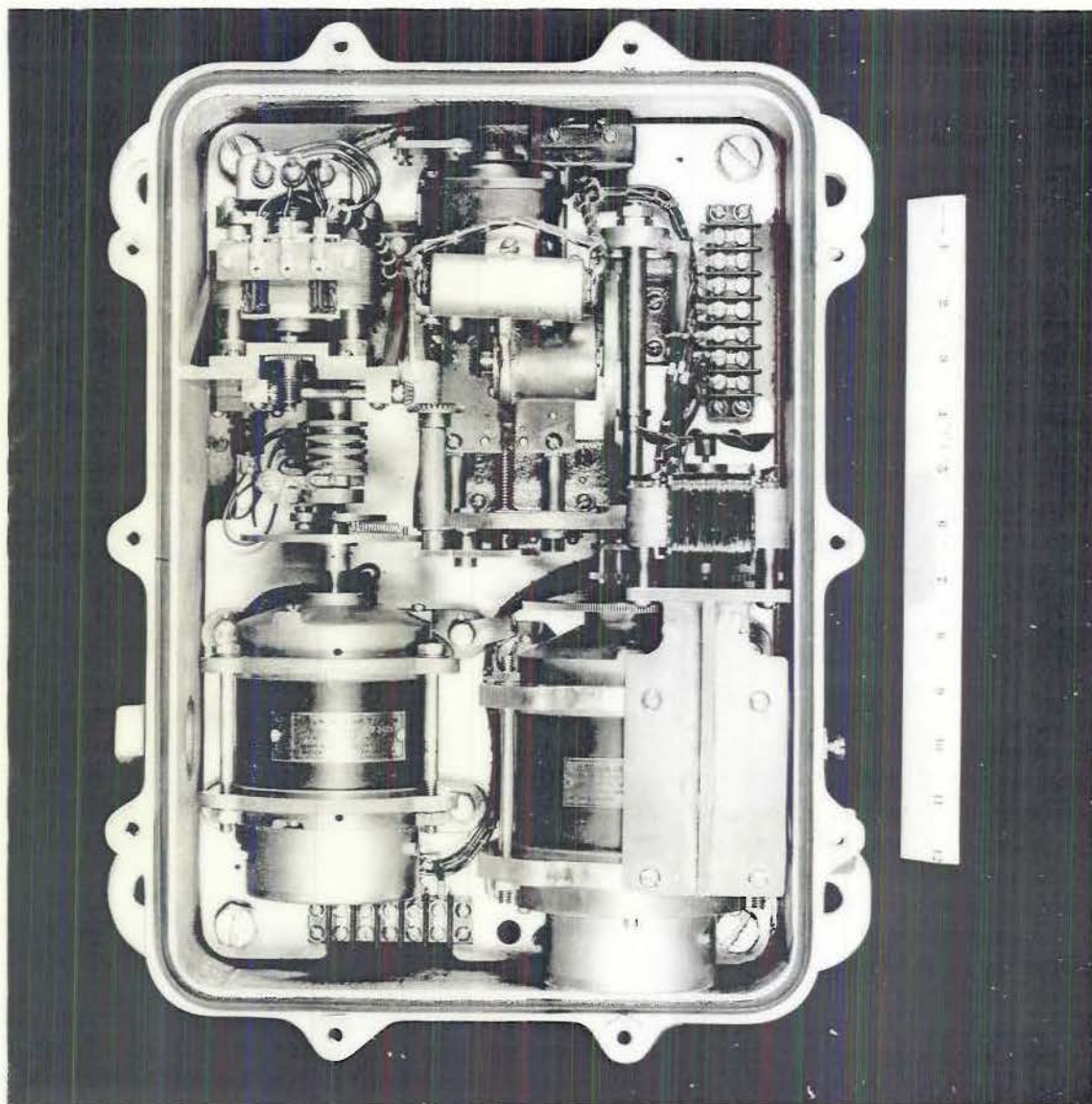
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PLATE 3



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PLATE 4



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PLATE 5