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THE RECORDING GRAVIMETERS OF THE DOMINION OBSERVATORY

OTTAWA

The two Dominion Observatory recording gravimeters are modified zero-length spring metal instruments - one North American (N° 85) and one Heiland (N° 30). So far as normal maintenance is concerned the instruction manual provided for the instrument should be consulted. It may be noted that relays will usually give warning of imminent failure by becoming warm to the touch, and should be checked daily.

The recording system measures the displacement of the beam of the gravimeter from its normal, horizontal position. The instruments are adjusted for a beam sensitivity such that the total range, between the two extreme positions of the beam where it rests against the stops is approximately 2 mgals. The hair-line which is normally mounted on the beam is replaced by a slit of such a width that the band of light occupies slightly more than half the total field of view; the maximum movement of the beam then causes this band of light to move from one extreme position in the field of view to the other, but at each extreme the light band is fully in view. The light-path emerges vertically from the instrument, and is normally bent through 45° by an inclined mirror, in order to facilitate reading the gravimeter. This mirror was removed and replaced by a mirror galvanometer, the mirror being mounted at 45° to the vertical so that the emerging light-path is horizontal. The galvanometers were constructed from 500 microamp core-type magnet panel meters; the pivots were removed from the coil, and a mirror, 1 1/2" by 1/2" mounted on one side of the coil. Suspension strips of 2/1000" x 10/1000" beryllium copper were fastened to the centres of the other side of the coil and the far end of the mirror; the assembly was strenghtened by a framework of thin brass. Tension is maintained in the suspension by a light leaf spring mounting at one end. A sketch of the basic galvanometer system is given (fig. 1).

The normal eyepiece may be used with the instrument, in order to speed the initial adjustment when setting up the gravimeter. The band of light should be centred in the field of view when no current is passed through the galvanometer; a hair-line on n° 85 indicates the optical centre, as does the normal scale on n° 30; in the latter case the band of light should be from divisions 10 to 40. If the galvanometer should not be properly centred, it may be adjusted; in the case of N° 85 by removing 4 screws from the top of the galvanometer housing and lifting the top-plate, and rotating the suspension leaf-spring system very slinghty; in the case of N° 30 by removing the oval ring and felt cover from the lid of the instrument and rotating the smallest visible screw-head (tighten the lock-nut after adjustment). Normally no adjustment is necessary.

If the eyepiece of the instrument is removed, it will be found that an image of the slit mounted on the beam is formed at the end of the eyepiece tube, and that this image moves sideways as the beam moves vertically. A split photocell, made from a Canadian Marconi cadmium sulphide cell (unmounted) is potted in araldite and mounted on a suitable tube which slides into the eyepiece tube. A mask having a square aperture is mounted over the photocell (see Fig. 2).

The cadmium sulphide photocell is a resistive device, having a very high dark resistance (around 200 Megohms) with a very great sensitivity to light. The amount of light available, if the lamp is properly centred (with the aid of the normal eyepiece lens), is sufficient to reduce the resistance of each side of the cell to about 1 Megohm. (this may be checked with a G.P. meter, between the appropriate points). A small balanced A.C. signal is fed to the two halves of the cell, so that if the halves are similarly illuminated, then the the junction will have no A.C. voltage upon it. A movement of the light band will cause an A.C. voltage of the appropriate phase to appear. If the output is checked with a C.R.O. at balance, a considerable amount of second harmonic A.C. will be found, due to the peculiar time-constants of the cells - in this respect, it has been found advantageous to use a low A.C. exciting voltage (approx. 1/2 volt). The signal is fed into a cathode follower, operating with reduced heater voltage, which is mounted directly on the back of the photocell, and the heater of which is D.C. operated from the normal gravimeter 6 V. supply. Shielded cable is used to carry the excitint A.C. and resultant signal from and to the control chassis (see Fig. 3); the signal is amplified by V_{1A}, and V_{1B} is a phase splitter to feed V_2 which is the "power" amplifier. The A.C. signal (at about 350 c/s) is generated by V_{3A}, V_{3B} being a buffer amplifier. V4 an V5 are the diodes for a normal ring demodulator which acts as a phasesensitive detector, the output of which is a D.C. current of polarity depending on the direction off-centre of the light-band and amplitude depending on the distance off--centre. This current is amplified by means of a normal direct-coupled transistor amplifier, individual transistors having a certain amount of feedback so as to render adjustments unnecessary if a transistor has to be replaced.

. The amplified current is fed into a recording milliammeter (up to 2000ohms, ± 1/2 ma full scale current, centre zero) and the mirror galvanometer in series. The galvanometer is shunted by a resistor selected so that the full scale range of the recorder is about 0.8 milligal, so that a drift of 0,5 milligal may be tolerated. The sensitivity of the amplifier should be such that if the galvanometer is shorted and so rendered inoperative, a change of less than 1/100 milligal swings the recorder over its full scale. C12 eliminates most short-period disturbances. Operation of the electronic unit from stable A.C. mains is desirable, although fluctuations from this source of disturbance are less than 1/100 mgal even for 10% variation, and are of a temporary nature.

The operation of the thermostat gives rise to a characteristic fluctuation on the record as the internal temperature varies, the amplitude of this fluctuation being around 1/100 mgal. A sticking thermostat may be recognised by a sharp deflection on the record, followed by a slow recovery (see Fig.4).

Operating notes.

The instrument should be levelled, connections made and the electronics allowed to warm up for 1 hr. Check the illumination with the optical eyepiece, and re-set the meter with the dial reading about the center position (500 divs.) so that the band of light is centred, with the galvanometer short-circuited. Clamp the instrument and replace the photocell, making sure that the dividing line is vertical (Fig. 2). The recorder should be on the extreme left, and on unclamping and rotating the dial clockwise will move the pointer to the right. If the galvanometer plug is inserted incorrectly, it will not be found possible to obtain a balance. In any case, it is necessary to wait for at least a minute before the pointer will come on scale after unclamping. Centre the recording meter pointer by adjusting the gravimeter dial. Tilt the gravimeter forward by 1 division on the bubble (wait 60 secs.). Tilt the meter back by 1 division of the bubble (wait 60 sec.). The centre position of level should be where the pointer is furthest to the left. Repeat tilting the meter sideways, and adjust the levels if necessary.

Sensitivity of the recorder.

The recorder must be at the centre when this is done. Run the recorder for 1 hour; then set the dial so that the recorder indicates about -.35 to -.4 ma (on the left-hand side). Always bring the dial up to the reading in a clockwise manner; if you overshoot, go back 5 div. or more and start over again. Remember that you are dealing with a delicate instrument and treat it gently. Allow the apparatus to run for 10 minutes, then rotate the dial exactly 10 divisions clockwise for N° 85 or 20 div. For N° 30; allow to record for 10 minutes.

Reset back the 10 (or 20) turns, and record for 10 minutes. (Remember to come up to the reading clockwise). This is the procedure to check the sensitivity, and should be performed each month. The initial dial reading should be noted on the chart before commencing the operation, and the meter should be recentred afterwards, again noting the dial reading on the chart.

Daily check.

Observe the record over the past 12 or 24 hrs. and if the record is appreciably off-centre, readjust the instrument dial. Note the initial and final readings on the chart. Check the record timing - if it is in error by more than 5 minutes, adjust it, and note the time and adjustment on the chart. Check the ink supply for the recorder, check the battery water-level and charging rate (should be 2 or 2 1/2 amps). Check the level of the instrument and if more than 1/2 div. off, readjust and note on the chart. Check the recorder paper supply. Check relays to see if they are warm.

Weekly check.

Wind recorder clock, and fill ink reservoir. Check the battery charge with hydrometer, reset the recorder clock if necessary. Note the time and date and instrument location on the chart. Repeat daily check as well. Put on booster battery charger and bring battery up to full charge, if necessary.

Monthly check.

Repeat weekly and daily check. Note dial reading on chart, and check levels. Check sensitivity by procedure outlined above. Note final dial reading.

If any emergency arises which you are unable to cope, notify the Dom. Obs. Ottawa immediately with full details. If the instrument overheats(accompanied by one or both heater lamps staying alight all the time), find the hot relay and replace it, then wait for the gravimeter to cool. Note on the chart. If neither relay is hot yet the heater lamps remains on all the time, replace the thermostat thermometer (see instrument handbook).

Servicing Electronics.

If recorder stays centred all time, check pin (2° 7) of V3A. No D.C. voltage at either indicates that V3 is not oscillating. Replace V3. Check other tube voltages, and remedy as necessary for all faults. If it is necessary to change a transistor, make sure you connect it correctly; hold the lead being soldered with pliers so that the heat cannot travel up the wire to the transistors

R1	3k	10w
R2	5k	10w
R3	60k	1/2w
R4	3.3k	"
R5	220k	"
R6	1k	"
R7	6.8k	"
R8	6.8k	"
R9	6.8k	"
R10	27k	"
R11	15k	"
R12	1.3k	"
R13	1 Meg	"
R14	1k	"
R15	"	"
R16	1 Meg	"
R17	"	"
R18	270	"
R19	"	"
R20-23	470	"
R24	8k tapped	10w
R25	100	1/2w
R26	270	"
R27	1000	1w
R28	470	1/2w
R29	47	1/2w
R30	"	"
R31	6.8k	"
R32	"	"
R33	1k	"
R34	"	"
R35	"	"
R36	470	"
R37	470	"
R38	6.8k	"
R39	"	"

C1	10mF	350 v.elect.
C2	30mF	350 v. elect.
C3	16mF	"
C4	.01mF	350 v.
C5	.1mF	350 v.
C6	16mF	350 v. elect.
C7	"	"
C8	.1mF	350 v.
C9	"	"
C10	"	"
C11	250mF	12v. elect.
C12	2000mF	6v. elect.

T1	Main transformer, 115v. A.C. in; 280-0-280v. 60ma out
T2	Hammond 434
T3	Hammond 834
L1	Choke, 5 H at 40 ma.
L2	Ferroxcube tuned circuit

V1	5Y3 or similar
V2	VR 150
V3,V4	6SN7
V5,V6	6SL7
V7,V8	12AT7
V9,V10	6AL5
V11,V12	6AL5
Tr1-Tr4	General purpose transistors, E_c max 25v., I_c max 5ma $\beta > 20$

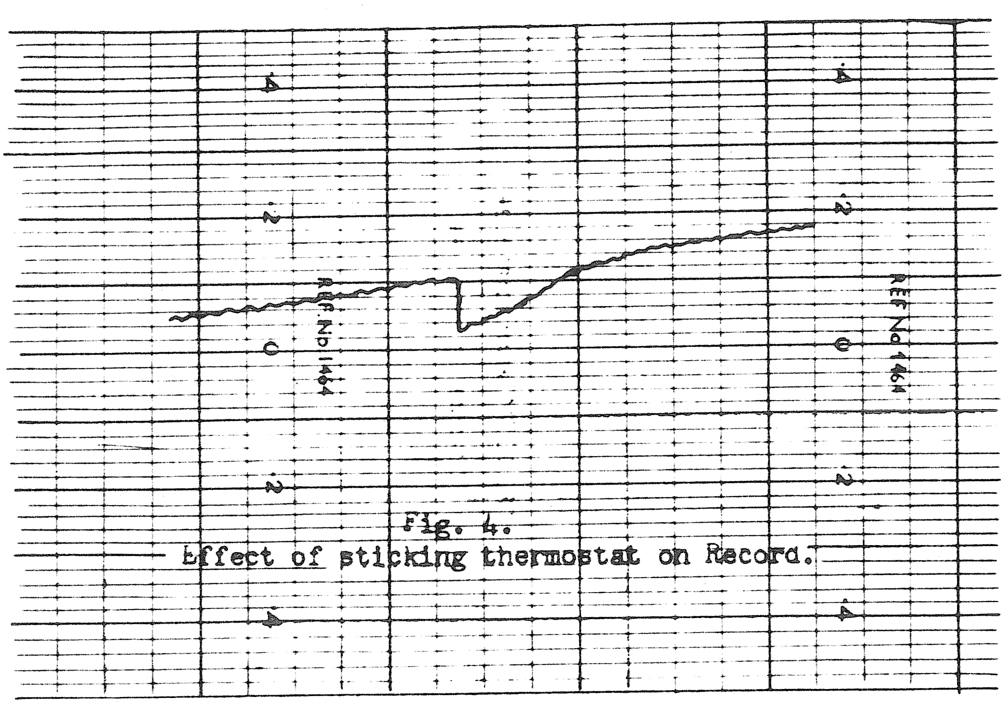

Fig. 4.
Effect of sticking thermostat on Record.

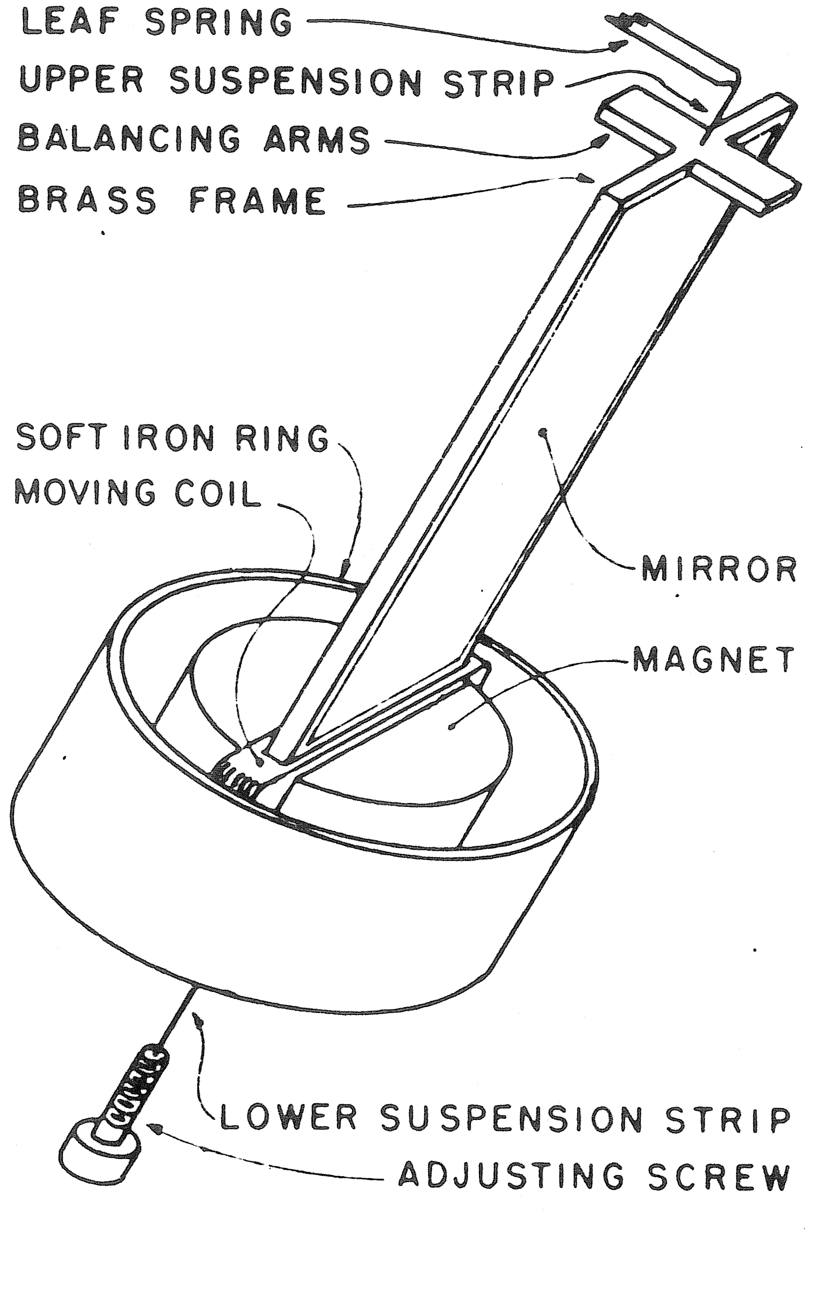
LEAF SPRING
UPPER SUSPENSION STRIP
BALANCING ARMS
BRASS FRAME
SOFT IRON RING
MOVING COIL
MIRROR
MAGNET
LOWER SUSPENSION STRIP
ADJUSTING SCREW

FIG. 1

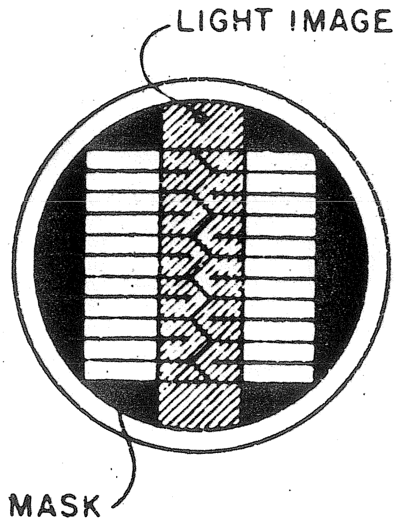

FIG. 2

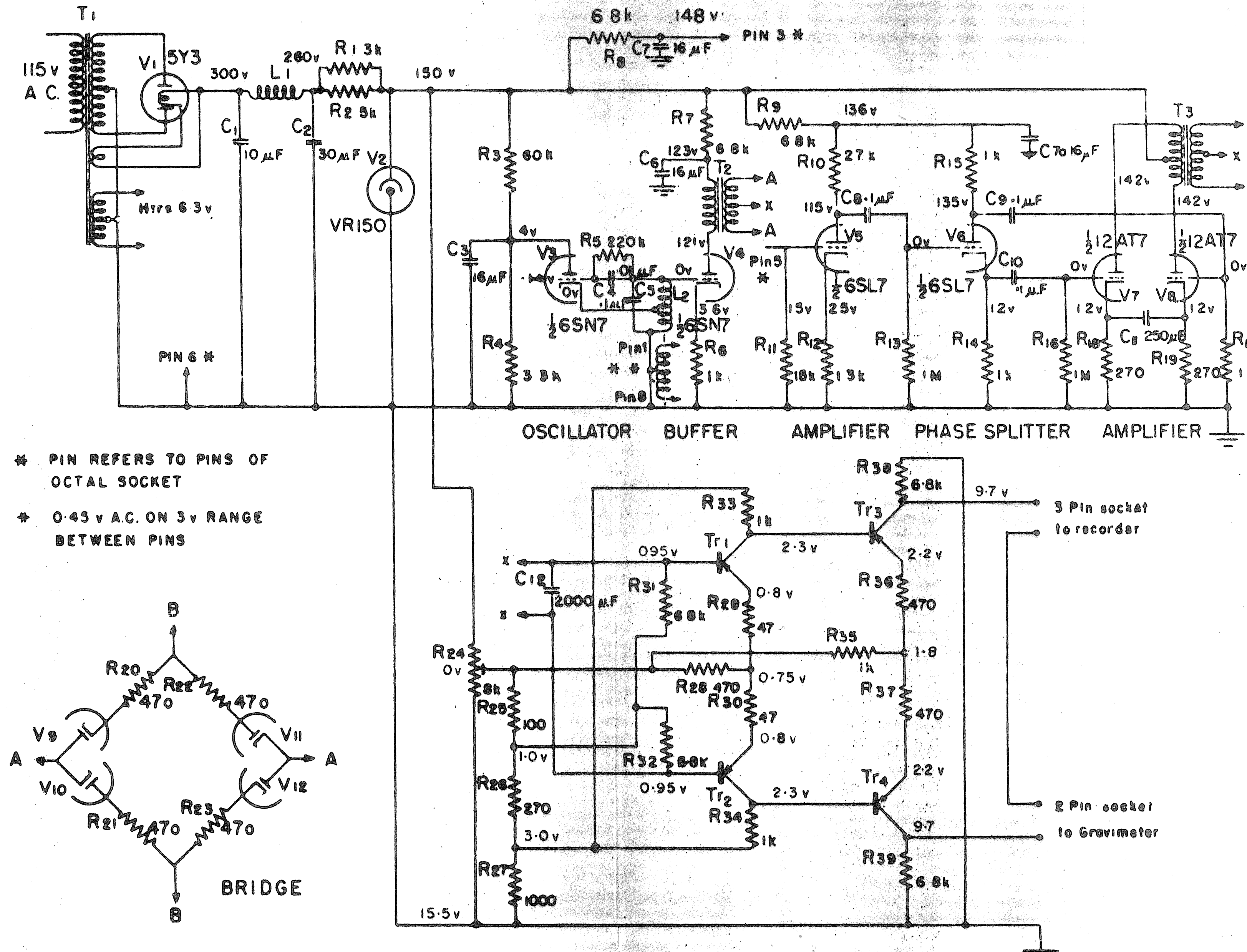

Fig. 3.

ALL VOLTAGES MEASURED WITH RECORDER CENTRED

VOLTAGES IN BLACK MEASURED FROM GROUND WITH 20,000 Ω/v METER

VOLTAGES IN RED MEASURED NEGATIVE FROM TAP ON R24

Kyōzō Kikkawa - The Relation between the Cyclic Change in Groundwater Pressure and the Tilting Motion of the Ground
(The Japanese Journal of Limnology 17, n°3 pp.91-99, 1955 - en japonais).

Résumé en anglais.

Some of the data for Earth tide observed near the sea have shown the strange results, contrary to our expectancy that the earth surface tilts chiefly with the tidal load of the sea water. We compare the both tidal variations in the discharge rates of hot springs and the observed anomalies of Earth tide in Beppu which were investigated in detail by Dr. E.NISHIMURA, and conclude that the main parts of the latter may originate from the variations in the thickness of the artesian aquifer with the tidal changes in the groundwater pressure. It is, thus, infered that a few similar phenomena observed in Japan may also refer to the elastic deformation of the artesian aquifer.

République Démocratique d' Allemagne.

Le Geophysikalisches Institut de la Karl-Marx-Universität communique que sous peu, une paire de pendules horizontaux doubles de Lettau sera mise en service en son Observatoire Géophysique de Collm.

(lettre du Dr.H. KOCH au Dr. MELCHIOR du 11.4.58).

DOCUMENTS RECUS AUX CENTRES MONDIAUX:

HONGRIE: Station TIHANY. Tableaux mensuels Ia, Ib, II, III, IVa, IVb de janvier 1958
(Gravimétre Heiland GSC 3 - 40).

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