distribution of kinetic energy are partly due to this unexplained discrepancy in speed response.

Conclusion 5. The relatively low estimates of energy density at high frequencies given by the LSK records seem unlikely to be wholly due to the response characteristics of the instrument or to smoothing during processing. The energy level corresponding to the speed digitizing interval in the curve follower used for reading the LSK records is at least an order of magnitude below the observed minimum values. One might speculate that the LSK was exposed to a lower amplitude of high frequency fluctuations due to its manner of mounting directly on the mooring line instead of being offset on a bracket, but we have no positive evidence of this and the effect remains unexplained.

Recommendation 1. Another intercomparison should be designed to resolve the discrepancies mentioned in conclusions 3 and 5 above. Comparison should be made on both surface and subsurface moorings and instruments should preferably be mounted in the manner in which they are most commonly used. Not all the types of instrument used in the 1970 experiment need be involved; it would be sufficient if Alexeev, LSK and Geodyne were used."

ANNEX V

REPORT ON SCOR WORKING GROUP 27
TIDES OF THE OPEN SEA
MEETING IN VENICE, 18-19 OCTOBER 1971

All members were present except Capurro, Eyries and Horn; Drs. J.L. Hyacinthe and F. Schott attended as observers. Dr. Cartwright served as secretary for the meeting.

1. Review of recent documents

The Chairman read out the following items, and recommended that they be reproduced in the minutes.

1.1 From SCOR Proceedings, Volume 7 (September 1971), p. 21, re WG 27

Terms of Reference: To encourage and assist with the design of instruments for measuring tides on the continental shelf and in the deep sea; to establish criteria concerning precision, sampling times and related considerations; to coordinate the observational programs and ultimately to bring about some uniform analyses of the deep sea data.

Members: Nominated by IAPSO: W.H. Munk, USA (Chairman); L.R.A. Capurro, Argentina; G.C. Dohler, Canada.

Nominated by SCOR: D.E. Cartwright, UK; J.R. Radok, Australia; T. Teramoto, Japan.

Nominated by UNESCO: W. Hansen, FRG; M. Eyries, France; S.S. Voit, USSR; W. Horn, FRG.

1.2 From SCOR Proceedings, Volume 6.2 (December 1970), pp. 72-73, Report on WG 27

There have been no formal meetings for the last two years, but the time may be ripe for a new review.

Theoretical efforts to compute the global tides by Pekeris in Israel, Hendershott in the United States, and Zahel in Germany have made considerable progress. I have not learned of the recent results in the Soviet Union where similar work is underway. It is my impression that a meaningful comparison between deep-sea calculations and deep-sea measurements is only a short time away. The boundary dissipation problem has not been solved, but it now looks as if the total energy in the oceans is rather larger than had been estimated; so the relative dissipation

is not quite so dramatic. Some connection between the age-old problem of the age of the tides and tidal dissipation has been established by Christopher Garrett.

The ESSA (Miami) group is getting set for employing Filloux tide gauges during September to study the $M_2$ node in the Gulf of Mexico and the tide in Yucatan Channel. Current meters will be deployed in the latter location. One principal goal is to study the $M_2 - S_2$ difference in this location.

The ESSA (Seattle) group under the leadership of Captain Barbee has been making measurements of internal tides off the continental shelf. Apparently, such internal tides are generated at the break of the shelf by mode coupling and propagating seaward along predictable "rays".

At the Scripps Institution we have occupied stations offshore from California, and these form the basis of the paper by Munk, Snodgrass and Wimbush: Tides Off-Shore: Transition from California Coastal to Deep-Sea Waters, Geophysical Fluid Dynamics, Vol. 1, 161-235, 1970. I think the work has served to clarify the cotidal structure in this part of the world. We now plan for a special cruise this October to occupy stations surrounding the alleged $M_2$ amphidrome.

Frank Snodgrass made a successful drop and recovery of three capsules at 40°, 50° and 60°S between Australia and Antarctica. The duration was approximately a month. Most of the equipment worked, and the tides show a sensible continuity between the Antarctic and Australian continents.

Our main emphasis for the next year will be the design and construction of a capsule which is to remain on the sea floor unattended for one year.

Walter H. Munk, Chairman

### 1.3 Report on progress of WG 27 presented to IAPSO at IUGG General Assembly, Moscow, August 1971

The subject has progressed, but too slowly and in too few quarters to justify planned international programs or any general meeting since that of Berne in 1967. The Committee will next meet in Venice in October 1971, when the state of the science will be reviewed. The present brief survey is therefore not comprehensive.

The global computations published by Pekeris and Accad in 1969 probably carry the direct solution of Laplace's unmodified equations to its practical limit. As with recent cotidal maps by other authors, agreement with observations, where they exist, is only partial. The importance of better understanding and representation of the energy dissipation at and near the shelf boundaries and of the distortion of the sea floor is now apparent; appropriate computer models are being developed by Pekeris and by Hendershott. An interesting new result from Hendershott's global computations is that the total oceanic tidal energy is about an order of magnitude greater than was previously thought. This effectively reduces our estimate of the Q factor of dissipation. Garrett and Munk have re-examined the problem of tidal 'age' in terms of Q factors and modal structure.

As a result of a small working session at La Jolla in 1969, Cartwright, Munk and Zetler laid down a suggested procedure for analysis of short pelagic tidal records. Such records have been obtained at several deep stations off the Californian coast, principally by Snodgrass, but also by Filloux and by the Lamont group, using their own instrumentation. Munk, Snodgrass and Wimbush have used these data to analyse the local tidal regime in terms of Kelvin and Poincare modes. Their latest results 'box in' the amphidrome between California and Hawaii. Snodgrass has also obtained records between Australia and Antarctica, in collaboration with the Flinders University of South Australia.

Cartwright has identified an unusual shelf-wave mode in the diurnal tide west of Scotland, and with other workers from NIO is building up a chain of tidal pressure and current

stations around the N.W. European shelf edge. He has also obtained and analysed new data from islands in the South Atlantic, and applied them to a beta-plane Poincaré mode synthesis of the central area. The resulting local cotidal map supports the controversial $M_2$ amphidrome of Pekeris and Accad (and of Zahel), but suggests it is further south, closer to one postulated by Bogdanov and Magarik.

The NOAA(Miami) group is using Filloux gauges to study the $M_2$ node in the Gulf of Mexico. NOAA (Seattle) is measuring internal tides off the shelf edge; conversion from surface to internal modes is thought to be a significant factor in tidal dissipation.

The use of altimeters in GEOS satellites to survey the ocean tides has been seriously discussed. In principle, this technique could revolutionise the tidal measurement problem, but current estimates of precision, of order 1 to 5 m, makes one pessimistic about early success.

We are far from our ultimate goal, a realistic definition of the tides in all the oceans. But computing and measurement techniques, with solution of some intermediate problems, are slowly reaching out towards some sort of link-up. With continued effort, hopefully on a wider international scale, one might see a solution within the next decade.

David E. Cartwright
p.p. Walter H. Munk (Chairman)

1.4 Extract from letter from B.D. Zetler (ESSA, Miami) to W.H.Munk, dated 15-3-71

Although I am not a member of the Group, I would like to suggest that the agenda for the next meeting include a discussion of whether an incompatibility exists between the agreed-on program to obtain 29-day series and an objective to zero-in on amphidromic points.

As you may recall from an earlier letter, Bob Cummings of NOS and I have been experimenting with this problem, using a year of hourly heights at Magueyes Island, reasonably near the semidiurnal node in the eastern Caribbean. The enclosed tabulation shows the results of individual analyses of the first 29 days in each month, compared with results from a least square analysis of the complete year. Although the station is believed to be some distance from the $M_2$ node, a significant amount of variation is found in individual 29-day analyses.

Cummings and I have been thinking about an optimum set of two one-month series of observations, based on the fact that the principal amount of interference from nearby frequencies deals with separations of 2 cpy.

However, looking at the enclosed data makes me believe that in any case it is necessary to lower the energy level of the continuum in the vicinity of the lines and this can be achieved only by longer series of observations. I am glad you have designed a one-year gauge.

(The table referred to shows semidiurnal and diurnal constants derived from a year's succession of 29-day records. $M_2$ (H = .023 ft, K = 279°) shows Standard Deviations = 0.32H, 38°, while $K_1$ (H = .260 ft, K = 166°) shows S.D. = 0.09H, 6°).

The main points arising from the discussion were that (a) amphidromes are no longer considered the best objectives (see 1.5), and (b) most people were finding the logistics of one-month pelagic records difficult enough, but that as techniques improved, two one-month records separated by a 2 month gap would be considered a worthy higher objective.

1.5 Three contemporary notes on deep sea tide problems by M. Hendershott (Scripps Institution of Oceanography)

(i) A number of numerical models of the global $M_2$ tide now exist (see Hendershott and Munk 1971 for bibliography). They are rather different in their construction and their parameterization of

dissipation but there is nevertheless an encouraging qualitative agreement between the various model results and island observations regarding the gross features of the global elevation field as well as between the computed global rates of dissipation (when they have been evaluated). The most salient features of computed cotidal charts are the amphidromes but the regions of large tidal range and slowly varying phase separating the amphidromes are of greater interest because they are the locations at which tidal potential energy is concentrated. Deep sea tide measurements at these locations would permit substantial improvement in the calibration of existing numerical models. The cotidal chart of Hendershott (Hendershott and Munk, 1971) suggests that the most important of these regions are centered at approximately 0°N, 15°W; 15°S, 75°E; 5°N, 135°W; 10°S, 115°W. There are other similar regions of smaller amplitude. Other numerical cotidal charts yield somewhat different locations. These regions, as determined by careful consideration of all existing numerical predictions, are the natural sites for the initial open ocean measurements in a systematic international program of deep sea tide measurements.

(ii) Two problems of importance and difficulty in existing numerical global tidal models are (a) the transition from coastal to deep sea tides over a shelf, and (b) incorporation of marginal seas into global models.

(a) Munk, Snodgrass and Wimbush (1971) have shown that California coastal tides may successfully be extrapolated seaward of the shelf, by fitting them to a sum of dissipationless free and forced motions over the shelf. This procedure could probably be applied almost without alteration to a number of other coasts (i.e., the western coast of South America). However, there are a number of shelf regions where the assumption of no dissipation is a poor one (Irish, 1971); further theoretical and observational study of the tidal transition across such regions is essential.

(b) Hendershott and Speranza (1971) have shown how measurements of tides in a rectangular marginal sea may be utilized to derive a deep sea boundary condition for semidiurnal global models. Measurements to confirm the validity of this procedure are now underway in the Gulf of California. A number of marginal seas may be treated in a similar manner but the irregular geometry of several other important dissipative regions requires more elaborate theoretical and observational treatment.

(iii) The customary parameterization of bottom friction is probably adequate in models which compute the velocity field with sufficient precision. No corresponding parameterization exists for the conversion of barotropic tidal energy into internal modes although this scattering may be the most important interaction between the barotropic tide and the general circulation of the oceans. This is a difficult theoretical problem whose resolution is of great importance for a definitive model of the global tide.

(These remarks were noted with great interest, particularly the importance of points of high potential rather than amphidromes. Hansen has a concept, 'wirkungspunkt', which appears to be similar in principle; he was asked to propose further sets of positions from his and Zahel's experience. Voit proposed to make a similar study with Kagan. It was regretted that Hendershott's four positions were so distant from the few countries equipped with open sea tide gauges.)

2. Progress reports from individual members

2.1 Hansen reported the application by Zahel of time-stepping techniques (the 'H-N method') to the world oceans, specified by a 4° mesh. A 1/2° mesh with better extension to shallow water areas was being considered. He recommended some measurements near the Gulf Stream, whose interaction with ocean tides may be important.

In discussion, Munk suggested that even a 1/2° mesh would ignore much coastal detail responsible for dissipation, which might be better represented by Hendershott's empirical boundary conditions than by the usual $\underline{u}.\underline{n} = 0$ condition. Also, the power loss by conversion to baroclinic tides at the shelf edge could hardly be accounted for other than empirically. In reply, Hansen said that extension of H-N methods to layered models was in progress. In connection

with the incorporation of marginal seas into global models, being necessary to consider details of the shelf regions in respect to dissipation effects for example, it should be mentioned that H-N methods which are taken as a basis for Zahel's global tidal investigations, have been successfully applied to tidal problems even non-linear in adjacent and marginal seas by Hansen and his cooperators within recent time. In principle, according to recent investigations, it is possible to operate an H-N model including different grid-sizes. In such a model the ocean, adjacent seas and even tidal estuaries are included.

Germany had no deep-sea tide gauge at present, but in the absence of Horn, Schott reported on work at I.F.M. (Kiel), and D.H.I. (Hamburg) using arrays of current meters to identify baroclinic tidal modes in the North Sea, in the Norwegian Sea and over the Meteor Seamount, and with shallow water (Graafen) pressure sensors on the West African shelf and off Southeast Iceland. Two more big experiments with current meters and tide gauges are planned off NW Africa (1972) and in the Shetland-Iceland ("overflow") area (1973). A new deep-sea tide gauge is now under development with an industrial firm. The means were provided by the Ministry of Science. The measuring principle will be either the N. and P. quartz pressure sensor or the Texas instrument quartz Bourdon tube. Both sensors are now under test.

2.2 Hyacinthe reported that his group CNEXO (Brest) had taken over the Eyries deep sea capsule in 1970, and had nearly completed a miniaturised version. This would be capable of 0.5 m and $10^{-3}$°C precision at depths up to 6000 m, with more than six months' readings at 5 minute intervals. Low power consumption was achieved by COSMOS electronics. Recovery may be by line, after acoustic recall of a sub-surface float. Estimated price is about $15,000.

Four records each of a few days' duration, had been taken with the Eyries gauge in the Bay of Biscay, and used by Hyacinthe for an analysis of the $M_2$ tide regime there. The programme for 1972 is to cover other parts of the North Atlantic, with special study of the deformation of the tidal wave at the shelf edge. Development of a static current meter for use with the pressure capsule was probable.

2.3 Voit. The USSR had no plans for a deep pressure sensor, but were concentrating on theoretical tidal work. Bogdanov is considering new computations of ocean tides with smaller mesh sizes and is comparing the two usual types of boundary conditions (elevation, and zero normal velocity specified). Kagan is working with an oceanic tidal model involving varying turbulent friction coefficients and stratification. A method of determining the friction coefficients has recently been published. Voit is himself investigating a transformation of the tidal equations to integral equations of Fredholm type. Theoretical solutions of these equations have been found, and they have the great advantage that they involve only integration around the boundary. A fuller report will be ready for the next meeting.

Voit promised to supply a recent bibliography of Russian work on tides, for circulation to WG members.

2.4 Radok summarised five years of progress of his group (Horace Lamb Centre, University of South Australia). In the absence of an ocean going ship, they have concentrated on shelf-tide measurements down to 200 m. Capsules employing differential and absolute pressure gauges, sampling every 4 minutes using Kennedy tape decks and their own logger, have given several records up to 30 days' duration, from nearshore to 100 miles out, at various parts of the south and west Australian shelves. This capsule also records at 4 second intervals swell waves every 7-1/2 hours. They now intend to equip one capsule with a Siemens strain gauge, a Schlumberger piezo gauge, and one of their own sensors to run a comparison test.

Radok also showed the WG a novel flowmeter designed by R.K. Steedman of his group. Derived from the Pitot tube principle, the meter operates on the temperature differential between two diffused silicon transistor sensors subjected to different velocity fields, and uses the linear dependence on temperature of their base emitter voltages. The response of each tube is proportional to the square of the velocity (threshold about 1 mm/s), with cosine directional dependence. Three tubes in a cross give complete direction information. They are small, light,

inexpensive, and have low power consumption.

The group's prospects for 1972 include several pressure/current records in the Great Australian Bight, 200 miles apart. Radok hopes to continue with industrial support further extensive surveys up to 100 miles offshore around Australia. He also plans an experimental tidal programme in Lake Baikal (Siberia).

2.5 Dohler reported on offshore tide recording in the St. Lawrence and Bay of Fundy area, and projected work in the arctic. His Tides and Water Levels Section (Department of the Environment, Ottawa) have developed and used a self-contained system involving a differential pressure transducer (up to 200 m) temperature sensor, and paper tape punch, housed with batteries in a stainless steel capsule, total displacement 210 lbs. It can record 1/2 hour samples for 3 months. Release is by acoustics or skin divers. Accuracy is of order 20 mm, which, being as good as or better than most surface tide gauge installations is considered adequate. Cost is about $11,000. Further details are in report by W. Zubrycky. Results of comparative tests between various instruments were shown, confirming the stated accuracy.

Dohler also showed a new 'Data Inventory Retrieval System' listing details of all tidal measurements available in computer applicable media from Canadian waters. This raised the question of an international inventory, noted more fully in 3.2.

2.6 Teramoto reported that efforts in Japan had largely concentrated on the accurate recording of currents, although a simple shallow water sea bed (up to 150 m) pressure device had been in use for several years before the World War II and had recently been improved at the Hydrographic Office. The improved device was successfully used in the Straits of Malacca. The acoustic current meter ($10^7$ Hz) had given good results in the Bay of Sagami, but its limitation was its 50 m watt power consumption. A project denominated as OSPER has started this year to develop a system for long simultaneous recording of (u, v, t, p) in the open sea. Teramoto, who participated in the project, promised to make the system applicable to a study of the open sea tides.

2.7 Cartwright described his own tidal work at NIO (Wormley) and reported on that of ICOT (Bidston). At NIO, Collar and Spencer have developed a shelf-tide capsule, consisting of a capacitance-plate pressure sensor (60kHz) whose F/M output is recorded digitally to $10^{-5}$ precision at 15 minute intervals. Bell and Howell strain gauges have recently been used successfully as pressure sensors. The data logger, which also records two temperatures, is a moderately priced device available in the UK, housed with all electronics and batteries in a 56 cm Aluminum sphere. Acoustic recall system is based on many years' experience at NIO, and has been 100% successful in the last three recording arrays. They are being used to define the tides around the shelf edge surrounding the UK, and so far 11 records, about 100 km apart, of up to 30 days' duration, each accompanied by corresponding current records from Aanderaa meters in adjacent moorings, have been retrieved between Ireland and the Shetlands and at the approaches to the English Channel. The chain should be extended to reach Norway in 1972. Sea bed pressure records have also been obtained from isolated islands in the shelf area, where no previous data was available. The diurnal tides show a strong continental-shelf-wave mode, among other features.

Cartwright has also obtained and re-analyzed all available data from the South Atlantic islands Ascension, Tristan and Trinidade, and made new recordings at St. Helena. The results, to be published shortly, confirm the positive $M_2$ amphidrome postulated by the computations of Pekeris and of Zahel, and Dietrich's negative $K_1$ amphidrome.

ICOT have placed a contract with Marconi Company for a 20-channel tide recorder with computer-compatible magnetic tape, and 5/million resolution . By mid 1972 they hope to have three such devices fitted with Vibrotron pressure sensors and Hewlett-Packard temperature sensors, and have plans for H-P pressure crystals also. Numerical models have been used to determine optimum siting for offshore instruments (chiefly re storm surges). ICOT are participating in the UK/Germany/Holland/Belgium study of the North Sea, principally by providing coastal and offshore-tower tide gauges. The main object of this exercise is to obtain a long term buoy network of current meters and other sensors within the North Sea. ICOT are also making an intensive

numerical study with measurements of the Irish Sea.

2.8 Munk summarised his group's (IGPP, La Jolla) deep sea tide work of the last 3 years. The three successful drops between Australia and Antarctica (plus island stations) proved on analysis to be rather 'unexciting'. The tidal constants merely showed a steady trend between Australia and Antarctic values. The results are to be published shortly by J. Irish (Ph.D. Thesis). The six or so deep records off California formed the basis of an interesting study in modal structure along a straight shelf in a semi-infinite ocean, (Munk, Snodgrass and Wimbush, 1970). The system was resolved into a tide locally forced by the yielding Earth, a Kelvin-type mode, and an optimised Poincaré mode. This probably defined the $M_2$ amphidrome better than any present co-tidal map. A later expedition to fix this amphidrome with an array of three sensors resulted in the loss of two of them, but the sensor retrieved showed the appropriate large phase difference, which confirms the expected position.

Snodgrass is now working on a new instrument, involving Hewlett-Packard crystals, COSMOS logic, and magnetic core storage. It is to give a year's record at 2h intervals, but will switch to 2-minute recording whenever a high frequency band (internally computed) exceeds a certain energy level. Every day at noon, it will transmit some of its core acoustically to a surface buoy then via satellite to land. Without such a monitoring system, a year's recording on the ocean floor would be psychologically intolerable.

Currents are still recorded by a hot-wire (also crystal) system with a vane, but the system is far from ideal.

A study of baroclinic tides (see 3.4) by Garrett and Munk showed a very complex modal structure, (in contrast to Schott's work, which uses a 2-mode synthesis).

Regarding other tidal work in the USA, Munk mentioned a study of the Gulf of California by Hendershott and Cox, the continuing work by NOAA(Seattle-baroclinic tides; Miami-Gulf of Mexico), and some new deep pressure capsules developed by Miller at Hawaii.

## 3. Important decisions and points of discussion

### 3.1 Existence and identity

The WG voted unanimously that it should continue to exist. However, the name "Deep Sea Tides" suggested that only the few who possessed deep sea pressure capsules could contribute to the work, whereas it was clear that many members were doing useful work with shelf-tide recorders, and the shelf edges were also very relevant boundary areas. It was therefore proposed that the name should be altered to - "Working Group on Tides of the Open Sea".

### 3.2 Information problems

Hansen stressed the need for some mode of dissemination of the results of recent tidal analyses, particularly from the open sea, which was made more acute by IHO having ceased to publish their sheets of tidal constants. He also mentioned the difficulty of obtaining up-to-date bathymetric figures for use in numerical ocean tide models.

The WG accepted a proposal by Dohler that he would incorporate all information on open sea tidal data sent to him in the uniform modern format of his group's new 'Data Inventory Retrieval System'. He was asked to provide precise details of what information should be supplied to him.

It was further agreed that Dohler and Cartwright (as Secretary) would draft a statement for presentation to the IHO, informing them of the special needs of the WG. (Such a statement has now been sent to the directors of IHO, 15 December 1971).

Dohler also promised to press this matter at meetings of IHO which he plans to attend as representative, and also to suggest to IHO that they should ultimately take over his proposed inventory system or establish a new one, and should consider the general need for a world bank of tidal data in modern format.

In any case, there should be a free exchange of data between members of the WG and their associates, once the originator has had time to assimilate the data himself.

3.3 Satellite altimetry

Cartwright had made enquiries about the state of this art, and had been assured from reliable sources that accuracy was unlikely to be better than an order of 2 metres in the near future, despite more optimistic figures quoted in some literature. Some improvement might be possible using, say, the Red Sea as a local reference level, but the prospects of useful tidal analysis were too doubtful to warrant active participation in this field by the WG. ( Note added after the meeting: Zetler and Maul, J. Geoph.Res. 76, 27, (1971) have recently suggested that useful analysis is in fact possible with a noise background of order 1 metre amplitude.)

3.4 Baroclinic tides

In view of the progress made recently in this field by Schott, Garrett and Munk, Wunsch, Cox and others, and the possible importance of baroclinic tides as an energy sink, the question was raised whether the WG should form a sub-group for their study. The Chairman advised against this, since it would distract unduly from the WG's prime occupation with the barotropic tides. The only point relevant to the group, he said, was the energy loss at the shelf edges and similar places, and this may soon be amenable to rough calculation.

3.5 Current measurements

The WG recommended that all open sea pressure measurements should be accompanied by measurements of current and temperature, with due attention to the effects of stratification.

It was recognised that no conventional current meter could give an adequate account of the barotropic component, and the WG recommended research into depth-integrating methods such as electrode arrays.

3.6 Analysis of open sea tidal records

While recognising the need for a uniform method of analysis of all open sea data, the WG were unable to agree on what that method should be. They recommend that each authority should analyse its own data in a reasonable way, and retain at least the following characteristics of the Cartwright-Munk-Zetler (EOS, 1969) procedure:

(a) The inference of a simple relationship to a nearby 'reference' station whose tidal characteristics are thoroughly known.

(b) Extraction of harmonic constants (H,G) for the constituents $Q_1$, $O_1$, $P_1$, $K_1$; $N_2$, $M_2$, $K_2$, $S_2$.

See 3.2 re dissemination of data and results.

3.7 Areas for concentrated study

Immediate progress in measurements would perforce be made in sea areas within easy reach of those groups capable of making them, (e.g., Australia, and north west Europe), but opportunity should be sought to reach Hendershott's four points of maximum potential, and also any 'wirkungspunkte' which Hansen's group may recommend.

Cartwright suggested (with approval of Hansen and others) that a fair-sized area of the North Atlantic could be surrounded by boundary measurements in the not too distant future. The work in UK and France was a starting point, and could be continued via Iceland and Greenland to Canada, while lines defined by Madeira - St. Johns or Dakar - Natal were also conceivable. Such an area could provide a useful testing ground for numerical models, theories of dissipation etc., besides being invaluable for world-ocean studies.

Munk mentioned the pressure records his group would be making in an open North Atlantic area as part of the MODE project; also probable deep sea tidal work by Miller in the Pacific.

Radok mentioned investigations under the ice of Ross Sea, planned for 1975-76, in which his group may participate with the Scott Polar Research Institute.

3.8 Coordinated testing program

All members with working instruments agreed to a joint open sea comparison test to be planned for mid 1973 (after MODE and not August). The location had to be easily accessible, and a steep shelf or island, where deep and shallow meters could be tested in close proximity, was recommended. The site and other logistics will be decided at a future meeting. Meanwhile, the primary logistic of 'booking' a suitably sized ship will be pursued by (i) Hyacinthe, (ii) Cartwright. If these two fail, Voit offered to find a Russian ship. Members will be informed of progress, and of the date of the preliminary meeting.

3.9 Change of officers

Walter Munk announced his wish to be relieved as Chairman, while continuing of course to serve as a member of the Working Group. He proposed David Cartwright as his successor, and that the post of Chairman should in any case be rotated at about 5 year intervals. This motion was seconded by Dohler and approved unanimously. Members expressed their appreciation of Walter Munk's service as the first Chairman of WG 27.

ANNEX VI

REPORT ON SCOR WORKING GROUP 28
AIR-SEA INTERACTION
MEETING IN MOSCOW, 1 and 7 AUGUST 1971

The following members, or representatives thereof, participated: H. Charnock (Chairman), S.A. Kitaigorodskii (rep. A.S. Monin), J. Namias, C.H.B. Priestley, R.W. Stewart, S.S. Zilitinkevich. K. Bryan and P. Welander were unable to attend. The following observers were present: Brocks, Burt, Busch, Coantic, Dobryshman (WMO), Foster, Kraus, Lacombe, Malone, Mitsuta, Miyake, Munn, Pond, Roth, Taylor, Zwang.

1. Matters arising from previous meeting

It was reported that an Air-Sea interaction symposium was in progress at the XV General Assembly of IUGG. It was noted that many of the papers were concerned with small-scale motion in the air over the sea; for future symposia an effort would be made to attract papers on a broader spread of topics, including more work on the upper layers of the ocean.

It was reported that further instrument inter-comparison trials had taken place at Tsimlyansk, USSR, between Australian, Canadian, Soviet and United States scientists. These had again proved valuable but further work was desirable especially on humidity instruments. There also appeared to be a growing need for comparison of instruments used in aircraft.