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**PHILIPPINE GEOGRAPHICAL JOURNAL**

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# LIVE WEIGHTS, CARCASS VALUES AND BREEDING HABITS OF BATANGAS AND BALI CATTLE[1]

by

VALENTE VILLEGAS[2]

Bali cattle are of a different species from Batangas and other Philippine cattle. It is interesting and important to learn the characteristics, live weights, carcass values and breeding habits of the two species for comparison.

## THE BALI OX

The domesticated *Bos sondaicus* Linnaeus is known as the Bali ox in Indonesia and serves for tillage, for pulling carts and as butcher stock in Bali, Timor, Borneo, Lombok, South Celebes and East Java. In the wild state, this species is called *Banteng*, inhabiting the forests of Java and Borneo. Both the Philippines and Singapore had imported Bali cattle for slaughter, and for breeding purposes also in the Philippines.

Under the Presidential Livestock Dispersal, Bali cattle were purchased in Indonesia by Drs. Aurelio Abrenica and Santos Colomeda of the Bureau of Animal Industry in 1956 and distributed to stockmen of 49 municipalities in the Philippines for breeding purposes.

For beef purposes, importation of 4,294 head of Bali cattle were made for three years, from 1954 to 1957, from which a total of 732,078 kilograms of dressed carcass were obtained, as follows: In 1954-55, 1,769 heads were imported and slaughtered in Manila producing 314,295 kilograms of dressed carcass. In 1955-56, 1,918 heads were slaughtered yielding 318,530 kilograms dressed weight. In 1956-57, 607 heads gave 99,253 kilograms dressed weight upon slaughter. The over-all average dressed weight was 170.8 kilograms per head, the range being from 164.0 to 193.6 kilograms. Credit was due to four importers in bringing to our shores these cattle for slaughter, namely: Philippine Hides Association Corporation (biggest importer), Henderson Trippe (Philippines), Paladin Commercial and Villegas Trading.

*Bull.* — The Bali bull known to the author has the following description: The color is deep-chocolate. The head is of medium length.

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[1] Villegas, Valente. Operation of Cattle Ranch, Unpublished.

[2] NSDB Technical Consultant on Animal Science and U.P. College of Agriculture Professor Emeritus on Animal Husbandry.

## BALI BULL

FIGURE I — FRONT VIEW

FIGURE II — REAR VIEW

FIGURE III — SIDE VIEW

Between the eyes, the distance is wide. The horns are directed to the sides, then backward, afterwards upward. The ears are medium-sized and erect, inside light-colored. The mouth is white, so are the legs up above the knees and hocks, the hoofs and rear part of the body. The dewlap is small. The chest is extraordinary deep but the rump is drooping. The tail is short, hanging over the hocks. The neck is well-muscled at the part on which the yoke rests. The withers is high up to the eleventh vertebrae where the back drops thus rendering the heart girth unusually large and the hindquarters light. The animal weighs from 110 to 465 kilograms.

*Cow.* — The Bali cow is much smaller than the Bali bull, the live weight varying from 205 to 270 kilograms. The color is light red and white at the rear and legs. The head is small, of medium width between the eyes and of medium length from the muzzle to the poll. The horns are slender and are directed upwards, slightly to the sides, forward, and then backward. Above the eyes are wrinkles. The ears are large, facing forward. The neck is small with dewlap in front of the brisket. The chest is unusually deep, the hindquarters are light and the rump sloping. The back is straight. The withers is very prominent. The legs are medium-sized. All four legs have white stockings up to 1-½ inches above the knees and hocks. The feet and dew claws are black. A dark line runs from the withers to the rear. From the tail head to one foot above the hocks is a white oval, but black around the genital opening.

Through the courtesy of Mr. Lee Sin Fook of the Government Stock Farm at Serdang, Malaysia, the live weights at different ages and breeding habits of the Bali cattle had been furnished to the writer as shown below.

*Birth and live weights.* — The birth weight of the bull is on an average of 17.4 kilograms a head, the range being from 14.1 to 20.5 kilograms. In the females, the average birth weight is 16.3 kilograms, the variation being from 12.7 to 20.0 kilograms.

In the bulls, the average live weight at one year of age is 151.3 kilograms, the fluctuation being from 110.9 to 201.4 kilograms; at two years of age, an average of 258.6 kilograms, the minimum figure being 172.7 kilograms and the maximum figure 312.3 kilograms; at three years of age, an average of 301.1 kilograms, the variation being from 241.8 to 356.4 kilograms; at four years of age, an average of 396.7 kilograms, one bull weighing 380.9 kilograms, the other 417.3 kilograms; at five years of age, an average of 423.3 kilograms, the live weights of three individuals being 438.2, 410.0 and 421.8 kilograms; and at six years of age, an average of 427.7 kilograms, two bulls weighing 465.5 and 390.5 kilograms.

The cows at five years of age have an average live weight of 247.7 kilograms, the variation being from 205.5 kilograms to 272.7 kilograms.

*Breeding habits.* — First oestrus in this species occurred at an average age of 25 months, the range being from 18.5 to 28.0 months. First calving took place at an average age of 33.3 months of age, the fluctuation being from 28 to 36 months. From calving to the subsequent oestrus, the average period was on an average of 101 days, the range being from 24 to 187 days. The gestation period was on an average of 286.8 days, the shortest period being 278 days, the longest 295 days.

## BATANGAS CATTLE

Batangas cattle are found principally in the provinces of Southern Tagalog. In 1963, the total number of cattle in these provinces was 174,100 or 11 percent of the total cattle population in the Philippines.

*Steer.* — "The Batangas steer is low-set, of medium length, unusually deep at the chest, but somewhat light at the hindquarters. The head is long and of medium width between the eyes. The horns are thick and short, the direction of the growth being sideways, upward and forward. The ears pendulous starting from the throat latch to down the chest. The neck is in proportion to the length of the body. There is no hump. The barrel is a little flat on the side. The abdomen is low, not paunchy. The back is short and could be more straight. The loin is wide and a little low. The rump is slightly drooping. The hips lack mascularity. The thigh is fairly muscled, wide and deep. The lower thigh is flat. Viewed from the rear, the hindquarters are narrow. The legs are big-boned. The front legs are relatively straight with feet that are small and upright, the dew claws big-sized. The hind legs are straight, the hind feet are small and slanting and the dew claws prominent. The tail is big, hanging down behind the hock. The switch is fairly bushy. The color is generally red, some yellow and black. Mixed colors of white and other colors are also seen."

The mean height of the steers is 123.80 ± 1,342 centimeters, the variation being from 116.0 to 135.0 centimeters.

The heart girth fluctuates from 157.5 to 189.0 centimeters, the mean being 173.12 ± 4.51 centimeters.

The minimum length of the body is 120.0 centimeters, the maximum is 150.5 centimeters. The mean is 135.74 ± 13.71 centimeters.

The mean live weight of selected steers is 376.76 ± 24.63 kilograms, the range being from 320.0 to 468.0 kilograms. The mean dressed weight is 189.65 ± 56.93 kilograms, the fluctuation being from 159.0 to 226.0 kilograms. The dressing percentage varies from 44.60 to 51.64, the mean being 48.69 ± 1.13.

*Live weight at different ages.* The average birth weight of bull calves is 19.1 kilograms; of heifer calves is 18.3 kilograms. At six months of age, the live weight of heifers is 63.0 kilograms. At one year of age, the average weight of bulls is 120.7 kilograms; of heifers 122.0 kilograms. At two years of age, the average weight of bulls is 166.2 kilograms; that of heifers, 176.0 kilograms. At 33 months of age, the average weight of cows is 204.6 kilograms. At four years of age, the average weight of cows is 264.0 kilograms.

The average height at the withers of heifers at one month of age is 63.5 centimeters. At the age of six months, with bulls, 84.8 centimeters; with heifers, 80 centimeters. At one year of age, with bulls, 94.8 centimeters; with heifers, 91.9 centimeters. At two years of age, with bulls, 106.3 centimeters; with heifers, 101.3 centimeters.

FIGURE IV — BATANGAS CATTLE

At three years of age, with bulls, 116.0 centimeters; with cows, 107.3 centimeters. At the age of four years, with bulls, 118.0 centimeters; with cows, 112.0 centimeters.

The average heart girth of heifers at one month of age is 72.0 centimeters. At six months of age, with bulls, 103 centimeters; with heifers, 95.5 centimeters. At one year of age, with bulls, 115 centimeters; with heifers, 111.0 centimeters. At two years of age, with bulls, 133.0 centimeters; with heifers, 135.8 centimeters. At the age of three years, with bulls, 156.0 centimeters; with cows, 148.0 centimeters. At four years of age, with bulls, 165.0 centimeters; with cows, 151.0 centimeters.

In length of body, from the point of shoulder to the pinbone, the average measurement at one month of age with heifers is 67.50 centimeters. At the age of six months, 91.3 centimeters with bulls; with heifers, 84.0 centimeters. At one year of age, with bulls, 98.5 centimeters; with heifers, 92.4 centimeters. At the age of two years, with bulls, 107.8 centimeters; with heifers, 106.5 centimeters. At the age of three years, with bulls, 117.0 centimeters; with cows, 112.0 centimeters. At the age of four years, with bulls, 123.0 centimeters; with cows, 123.5 centimeters.

*Breeding habits.* — Cattle breed naturally throughout the year. The period of oestrus is 11.3 hours. Oestrus occurs 80.2 days after parturition. Between oestruses, the interval is 20.6 days. The period of gestation is 283 days.

# TOWARD MEANINGFUL INDICES OF ATTENUATION AND FRAGMENTATION[1]

by

PAUL SNYDEN[2]

Geography, in the opinion of this writer, is quite difficult to teach. It has, in fact, been described by some as the "poorest taught" subject: and like the weather, there is much talk but very little doing of anything about it.

Many things in the discipline, especially the physical aspects, can be readily conceptualized in the abstract by the student but can not be effectively taught in the concrete by the instructor. A reason for this, at least in part, is that there are not enough scales to measure the subject matter. Some "show me" devices do exist in the earth sciences, however; a good example is Mohs scale for hardness. The student can not only be told that topaz is harder than quartz; but the teacher can handily demonstrate that it is so.

There are many ways the nations of the world can be ranked according to their degree of this or degree of that, but very few attempts have been made at this sort of thing. Perhaps scholars in the past thought the countries of the world too numerous to try to rank order them in terms of attenuation or fragmentation. But there are only a few more countries than there are elements; yet the latter have been weighted. Perhaps it was thought best to wait until the "proliferation of nations" was over before making any quantifications as regards shape. But the proliferation period has passed, there are only a few more to be added and since the world is a finite place, there will be little more change after that. It's analagous to the atomic table, as the remaining but expected elements were discovered, they were merely put in their proper place on the ready prepared chart.

Still, even if it is feasible to quantify attenuation and fragmentation, its practical purposes may be debated. A "purist" might get by this with the knowledge for knowledge sake argument, but this author believes, however; that the development of such indexes will afford much useful clarifications and perhaps even bring to light some empirical surprises. Notwithstanding that they will aid immensely as geography

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[1] All data on which this study is based were collected by writing the information officer at all the nations represented in the United Nations during 1969. Those nations not represented there at that time were contacted through the Embassies in Washington, D.C. who handle their informal affairs in the United States. In addition, to assure currentness and accuracy, the supplied figures were checked against the 1970 (Encyclopedias Americana and Britannica, U.N. Demographic Yearbook, World Almanac, Whitaker's Almanac, and the Atlases of Hammond and Goode).

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TABLE 1

THE ATTENUATION INDEX FOR ALL COUNTRIES WHOSE LENGTHS EXCEED THEIR WIDTHS BY AT LEAST A FACTOR OF THREE.

| Country | Rank | A.I. | Country | Rank | A.I. | Country | Rank | A.I. |
|---|---|---|---|---|---|---|---|---|
| Chile | (1) | 22.916 | New Zealand | (12) | 4.800 | North Vietnam | (22) | 4.000 |
| Gambia | (2) | 13.333 | Lebanon | (13) | 4.667 | Phil'ppines | (23) | 3.716 |
| Cuba | (3) | 10.242 | Italy | (14) | 4.666 | Finland | (24) | 3.625 |
| Japan | (4) | 10.000 | Mosambique | (15) | 4.570 | Malagasy R. | (25) | 3.532 |
| Malawi | (5) | 8.571 | Sweden | (16) | 4.544 | Tunisia | (26) | 3.393 |
| Panama | (6) | 7.800 | Togo | (17) | 4.533 | Cypress | (27) | 3.250 |
| Norway | (7) | 7.333 | Congolese R. | (18) | 4.515 | Dahomey | (28) | 3.192 |
| South Vietnam | (8) | 5.833 | Somalia | (19) | 4.346 | Peru | (29) | 3.036 |
| Indonesia | (9) | 5.785 | Czechoslov. | (20) | 4.257 | Portugal | (30) | 3.000 |
| Laos | (10) | 4.967 | Nepal | (21) | 4.160 | Span. Sahara | (31) | 3.000 |
| Israel | (11) | 4.846 |  |  |  |  |  |  |

teaching tools, the indices developed might also be used in some of the military geography formulae. However, the author, not having any particular expertise in the latter area, made no such manipulative attempts with the data.

The first index devised is the Attenuation Index (A.I.). It is obtained by dividing the length of a country by its width. These data are presented in Table 1.

The other nations of the world are compact, that is, their lengths are less than three times greater than their widths, hence are considered as not seriously attenuated.

The next indices presented is the fragmentation indexes. It takes two constructed indices to adequately express fragmentation, one for area and one for population. To calculate the Fragmentation Index (Area) or F.I.A., the area of the largest segment was divided into the total area of all the other segments. To calculate the Fragmentation Index (Population) or F.I.P., the segment with the greatest population was divided into the total population of all other segments. The results of these computations are depicted in Tables 2 and 3.

TABLE 2

THE FRAGMENTATION INDEX AREA FOR THOSE COUNTRIES WITH AN F.I.A. GREATER THAN 0.10

| Country | Rank | F.I.A. |
|---|---|---|
| Indonesia | (1) | 2.47 |
| Philippines | (2) | 1.81 |
| New Zealand | (3) | 0.77 |
| Malaysia | (4) | 0.66 |
| Denmark | (5) | 0.45 |
| United States | (6) | 0.20 |
| Greece | (7) | 0.19 |
| Italy | (8) | 0.17 |
| Japan | (9) | 0.14 |

TABLE 3

THE FRAGMENTATION INDEX POPULATION FOR THOSE COUNTRIES WITH AN F.I.P. GREATER THAN 0.10

| Country | Rank | F.I.P. |
|---|---|---|
| Denmark | (1) | 1.497 |
| Indonesia | (2) | 1.145 |
| Philippines | (3) | 0.701 |
| Japan | (4) | 0.505 |
| New Zealand | (5) | 0.266 |
| Malaysia | (6) | 0.161 |
| Italy | (7) | 0.115 |

The other nations of the world have over 90 percent of their total area in one segment, in the case of the F.I.A., or over 90 percent of their total population located in one segment, in the case of the F.I.P., thus are not considered fragmented to any significant degree.

It must be remembered that these indexes, like any other, would have to be recalculated as new data become available. Therefore, any change in political boundaries due to mergers, conquest, or even the acquisition or loss of territory due to volcanism or natural phenomena would alter the F.I.A., just as any disproportionate population shift would effect the F.I.P.

# AIR AND WATER POLLUTION

by

A. VAN HAUTE[1]

## SOURCES OF AIR POLLUTION AND THEIR CONTROL

In fact, one must classify air pollution into "natural" air pollution and into air pollution caused by human activities.

Natural air pollution arises from volcano eruptions, from forest fires, through transfer of plant pollen...; at the same time, it is estimated that ten million tons of extra-terrestrial matter fall from the universe on our earth per year.

In this contribution, however, we shall lay emphasis alone on the air pollution caused by human activities, which are the result of our economic prosperity. In this connection, one distinguishes air pollution brought about through combustion for heating purposes, air pollution brought about through industries, and air pollution brought about by motorized traffic. The air pollution before was not so acute a problem, on account of a certain self-cleansing activity of the atmosphere. Dust and aerosols sink or are washed out by rain. This washing activity of the rain is also applicable to water-soluble gases such as $SO_2$, HCl and HF that are moreover adsorbed to dust. Organic air pollutants are gradually oxidized through atmospheric oxygen under the action of UV-light over a whole series of intermediate steps to $CO_2$ and $H_2O$. The strong industrialization and population concentration near industrial sites overload considerably this self-cleansing capacity. Coupled to meteorological circumstances, this can lead to disasters (Maasdal 1930, London 1952, Los Angeles).

### *Air Pollution Caused by Domestic Heating*

Important factors herewith are the quality of the fuel and the suitability of the fuel-burning equipment. In this last connection, a regular control of the fuel installation is thus certainly to be recommended. Further, the height of the chimney of course plays a role in the dispersion of the impurities: the higher the chimney, the better the dispersion.

Difference must be made among the air pollution caused by solid, liquid, and gaseous fuel.

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The main problem in the combustion of solid fuels is the formation of soot and tar, which particularly arise from the use of bituminous coal. From the point of view of air pollution, one then prefers also mostly anthracite or coke over bituminous coal. These soot and tar substances contain a few components such as 3, 4-benzopyrene that have the property of causing tumors, among others, on the skin of mice by prolonged contact. It is particularly to these substances that the connection between lung cancer and cigarette smoking is attributed to. Although a similar connection between lung cancer and pollution of the atmosphere is not yet scientifically shown, it is clearly seen in any case that one must strive for the farthest possible reduction of the soot percentage of the atmosphere. Since coal also contains 1 percent S, these solid fuels also bring about a pollution through $SO_2$.

Although the burning with oil can certainly and strongly lessen soot formation, one may not say that mineral oil products are better fuel than coal. This is because the use of heavy mineral oils (with more than [illegible] percent S) in modern cities can lead to the strong increase of pollution with sulphur oxides. This of course can be limited by issuing measures with regard to the percentage of sulphur of the mineral oil as a function of the capacity of the combustion installation.

One can expect as well a considerable reduction of the air pollution with regard to soot and sulphur oxides when practically sulphur-free and little-sooty natural gas shall take the place of the solid and liquid fuels. The combustion gases from natural gas are practically oxygen-free and, moreover, contain a high concentration of carbon dioxide and vapor. Yet, sometimes, a small quantity of irritating nitrogen oxides caused by the combustion of nitrogen from air is produced so that a certain caution is still required. These nitrogen oxides are of course also present in the combustion gases of solid and liquid fuels.

### *Pollution Caused by Motorized Traffic*

Particular concern must be given to the air pollution caused by motorized traffic. One must make a difference between the pollution from the gasoline or Otto-engines and that from diesel engines because the substances that these engines bring with the exhaust gases to the atmosphere are not of the same nature.

Harmful gases coming from these sources contain both toxic compounds and organic materials that are not themselves objectionable but which react in the atmosphere to form a "smog." In addition, objectionable smoke and odor, separately or together, may accompany the exhaust emissions.

*Gasoline engines.* — The emission of harmful gases can occur in three ways: (a) as exhaust gases coming from the combustion of the gasoline; (b) as evaporative exhaust directly brought in the atmosphere from the gasoline tank, the carburetor or any other part of the gasoline system; and (c) crankcase blow-by. As gases that under pressure escape the combustion chamber past the pistons and enter the rank-case.

For the good functioning of a gasoline engine it is necessary that a small excess of fuel is present in regard to the atmospheric-oxygen in the cylinder (if not, the flame will not propagate through it properly). Complete combustion of the gasoline to carbon dioxide and water is thus not possible. The exhaust gases always contain a certain quantity of carbon monoxide (CO) and unburned, cracked or uncracked, hydrocarbons (as well as saturated or unsaturated, straight or cyclic). The quantity depends, aside from the adjustment of the engine, also on the driving circumstances (constant speed, acceleration, decreasing speed, free wheel). For a speed of 40 km hr., the average percentage of CO in the exhaust gases is 3.1 percent and that of the hydrocarbons is 1400 ppm. These values decrease with the increase of speed, but rise with the lessening of speed, and can in that way amount to 7 percent and 2500 ppm respectively by free wheel.

Nitrogen oxides also form in the gasoline engine, first as NO, which is next converted to $NO_2$. This initial combination of nitrogen and oxygen occurs only at relatively high combustion temperatures and when there is free oxygen present. The greatest quantities (to 300 ppm) should thus form with a light excess of oxygen, so that these high values shall not be reached: 850 ppm seems to be a good average.

As the fourth harmful series, one must report the partial oxidation products, such as aldehydes, ketones, alcohol, esters and acid derivatives, that mainly arise from incomplete combustion. Little is still known about these pollutants. Their concentration lies between 50 and 100 ppm and they possess an objectionable odor and irritant properties and are photochemically active.

Finally, one must pay attention to the extremely fine solid particles (70 percent has dimensions between 0.02 and 0.06 u) that appear in the exhaust gases. Their quantity lies between 0.22 and 3.2 mg/g. burned gasoline with an average of about 0.8. They are mainly of lead combinations, resulting from the use of tetra-ethyl lead that is added to the gasoline to obtain high octane-numbers necessary for the antiknock property. Thus far, no alarming increase of the lead percentage has still been shown of the air in the traffic streets.

It is desired to reduce this important form of air pollution. One works of course to the introduction of mechanical improvements of the engine so that fuel excess shall no more be necessary. But, so long as one has not yet reached this, there is but one solution, namely, post-combustion with secondary air of the incompletely-converted components of the engine exhaust gases. Very much work is done on this in America, either through direct combustion in a separate unit if possible close to the exhaust valve of the cylinder (so that the exhaust gases are not yet cooled too much, but on the other hand, there is a danger of valve burning), or through catalytic post-combustion. This last method is not yet to be recommended on account of the relatively small life (among others, through lead poisoning and exposition to temperatures higher than 900°C) and the high price of the catalyst, as also on account of the great need of maintenance. Although none of these methods is yet posed at point, a post-combustion is already required in the state of California, and American cars are equipped with it. Through this, the aim is to limit the percentage of CO to 1 percent and the hydrocarbon concentration to 275 ppm. For 1975, the goals are 0.5 percent and 50 ppm, respectively. In Europe, where most cars are smaller and thus offer lesser space for extra installations, these improvements shall perhaps require still a longer time.

In order to lessen the percentage of nitrogen oxides in the exhaust gases, a part of the exhaust gas can be recycled to the cylinder. Through this, the combustion temperature and the oxygen concentration are reduced, both of which are of importance in the formation of nitrogen oxides (see above). When 30 percent of the exhaust gas is recycled, the percentage of nitrogen oxides lessens by 90 percent. But owing to this, the maximum strength which is developed through the engine also lessens. The recycled quantity of exhaust gas must then also be adjusted to the percentage of nitrogen oxide. In 1975, the aim in the U.S. is to see the concentration reduced to 250 ppm. (The use of a reducing catalyst is not yet technically possible.)

The evaporative emissions are estimated roughly to be responsible for 10 to 30 percent of the total emission of hydrocarbons in the gasoline engine. The loss through evaporation affects mainly the lighter hydrocarbons.

One can reduce these losses through car-designs whereby the fuel tank is placed as far as possible from the heat source, and whereby only a minimum liquid surface is available. The use of fuels with smaller vapor pressure should of course require an adjustment of the carburetor and the feed system to keep a good fuel-air mixture.

In the cylinder a part of the gas mixture shall also flow along the piston toward the crankcase. Experiments have shown that these gases are primarily (± 85 percent) from the fuel-air mixture that escapes before the ignition, and for the rest (15 percent) from combustion products. These gases are therefore rich with hydrocarbons, accounting for about 1/3 of the total quantity of escaped hydrocarbons. With the new types of cars, however, systems are installed that make possible the recycling of these gases from the crankcase to the cylinder.

*Diesel engines.* — Diesel motors cause an entirely different and luckily a much less notorious character of air pollution: this is particularly due to the smoke and the odor of the exhaust gases. Smoke is an aerosol, containing solid particles smaller than 1 u arising from combustion. These fine particles obscure vision because of their light-scattering appearance.

In the cylinder, an oxygen excess must be present for a good operation so that practically complete combustion is possible; this goal is reached by adjusted, not-overloaded engines. Difficulties are however the acquisition of a sufficient homogeneous mixture of the injected liquid fluid and the air (unburned hydrocarbons), and the fact that by overloading or by filthiness or any inadjustment of the engine considerable amounts of soot (smoke) and other products of incomplete combustion, e.g. aldehydes (odor), are formed. Nitrogen oxides are also present in the exhaust gases, but rarely CO.

Operated with an unthrotted air inlet opening, the great excess of air strongly dilutes the combustion products in the case of diesel engines, in contrast to gasoline engines. Their concentrations indeed depend strongly on the engine type (they are much higher for a two-stroke engine than for a four-stroke engine), on the speed and on the load. Generally, one can say that the concentrations of the harmful substances in the exhaust gas diminish with the load (however, it is the reverse for the nitrogen oxides), while the absolute values depend on the speed and the load in a way that has not yet been determined correctly.

Diesel smoke is white, blue or black. The origin of white smoke is the occurrence of unburned fuel mist and is caused by the cold starting of the engine. Blue smoke is caused through excessive oil consumption and is thus undoubtedly an engine problem to be remedied. Black smoke alone is important in connection with air pollution. It is caused by an incomplete combustion of the diesel oil. The fact that the smoking does not appear with a well-adjusted and not-overloaded engine connotes that this pollution observed along the roads can be remedied by keen supervision of the condition of these engines, e.g. by technical control stations where cars legally must be inspected periodically. Besides, the smoke can be lessened through the use of additive to the diesel oil. Materials particularly barium-based, seem very active. The correct mechanism is not yet known, but it is accepted in the first place that these metal-additives decrease the ignition temperature of soot particles and further also that the smoke particles have a reduced tendency to agglomerate. About 0.1 to 0.2 weight percent of the metal is necessary in order to realize a sensitive improvement of the smoke emission. It

Different researches pointed out that the diesel soot should contain practically no carcinogene polycyclic aromatics, so that it should be is however not a cheap method.

considered more as aggravating than as harmful. An analysis of the air pollution at a stop on a highway in Sydney (Australia) supplies however strong indication that this smoke also contains a clearly demonstrable quantity of benzopyrene. Further research in this line is strongly desired.

The specific odorants in diesel exhaust have not yet been isolated or identified but are usually associated with the family of the oxygen-containing organic molecules. Intensive study in connection with this problem started already.

### *Pollution Caused by Industry*

Air pollution through industries offer a great variety of problems. On one side is the problem of air pollution connected to the use of fuels for energy-generation as well as to the combustion of waste. To the other side are the exhaust emissions of waste matter, by-products... a problem that shows very strong diversing facets, and in fact for every different kind of industry.

*Power stations and incineration of solid wastes.* — The use of fuels for generation of energy, links closely that of domestic heating. Yet, the much greater capacity of installations which come most in discussion and the technical possibilities that are offered through this, allow an effective fight of the air pollution through treatment of the combustion gases.

Smoke and soot danger connected to the use of solid fuels for domestic heating, are strongly lessened and even entirely removed in big industrial installations by using a strongly perfected automatic equipment. Nevertheless, the ash particles of the fuel that are too small to sink in the combustion chamber with the smoke gases escape. The quantity of this flue gas that possesses an average diameter of 15 u, depends of course on the character of the fuel-burning equipment and fluctuates between 500-5000 mg/Nm$^3$. Mostly there should be supplied a very good dust removal installation, e.g. a combination of cyclones and electroprecipitators for the emission of solid particles inside the limit of the allowed values. Different tons of the flue gas gained in this way are indeed used in cement, road building... The quantity of dust particles in the smoke gases of the fuel oil fed to a heating apparatus amounts mostly to much less than 300 mg/Nm$^3$ and is even much smaller when gas is used. The sulphur present in the fuels is mostly as sulphur dioxide ($SO_2$) in the smoke gases. This is also a problem of solid fuels, but particularly of liquid, such as heavy fuel oils with a rather high sulphur percentage (e.g. 3.5 percent) whereby the combustion gases can contain to about 2000 ppm (0.2 percent) $SO_2$. In the flame zone and smoke canals, however, a small part of the $SO_2$ (at most 10 percent) is also further oxidized to sulphur trioxide which reacts with water present in the smoke gases to form sulphuric acid. By cooling these gases, this sulphuric acid condenses to a mist that deposits on the walls of the heat exchanger and in the chimney. With the small quantity of soot and ash particles that are always present, a black, acid corrosive layer is formed in the chimney. Parts of this layer can again be set free from the wall and then form quite big soot flocs (to a few millimeters) which fall out rather fast in the atmosphere and then give occasion to severe complaints about pollution, corrosion... Means against this difficulty are rather aimed to prevent the attack of the installation by the sulphuric acid. Their working for the fight against air pollution has only a secondary effect: (a) temperature of the gases in the chimney above the acid dewpoint; and (b) the bringing into the chimney of finely divided weakly basic material that the sulphuric acid already neutralizes in the mist, e.g. finely divided magnesium oxide.

These means have as result of course no reduction of the percentage of $SO_2$. Many solutions were already suggested but none were generally accepted. Previously, washing was sometimes applied with weakly alkaline water. Through this, however, the gases were strongly cooled and saturated with water. The plume of smoke in this way loses the capacity to rise and gives more occasion for mist formation. At the same time, the $SO_2$ — and soot-loaded washwater can produce severe problems unless the process is coupled to a second operation whereby sulphur or sulphuric acid is prepared from this wastewater. A method that seems to have future is the following: very finely ground dolomite or lime is added to the fuel or in the furnace giving rise to metal sulfates which are expelled together with the flue gas. A solid waste is therefore obtained. If a dry dust removal installation is used, only 50 percent of the sulphur is expelled even with the addition of a stoichiometric quantity of dolomite. If, however, a wet scrubber is used, more than 95 percent is removed. Attention also goes to processes where the $SO_2$ with rather high temperature is fixed on a solid carrier (e.g. active coal), where it can again be removed in a second operation after which follows the conversion to sulphur or sulphur dioxide. Economically, all these processes are not yet entirely favorable, so that for this purpose, the most used and least expensive solution is to construct very high chimneys, 100-300 m.

As already said earlier, nitrogen oxides always form when air-nitrogen and oxygen are heated to a high temperature. The quantity becomes bigger as the ignition temperature becomes higher. In power stations, the concentrations of the nitrogen oxides amount to an average of 200-500 ppm (as $NO_2$) with the use of any fuel.

When the combustion is not well-regulated, it can of course happen that the smoke gases contain CO, unburned hydrocarbons, aldehydes, and other organic gases. For bigger industrial installations, this is however no problem, thanks to the automatic control. With a domestic heating, on the other hand, one must reckon with this danger.

In connection with this, the combustion of domestic waste can now be handled through which combustible waste, particularly cellulose, is converted mostly into gases (principally $CO_2$ and water). Only a small part of the charge remains as solid ash, namely 10-20 percent. Generally, no industrial combustion furnaces can supply smoke gases with a dust percentage below the allowed limit, so that a dust removal installation must be provided. The dust percentage is to be compared with that of the higher values in the smoke gases of the power stations working with solid fuels. Still little is known about gas emissions, but particularly of importance are hydrocarbons (to 1000 ppm), CO (average 500 ppm), and aldehydes (to [illegible] ppm) so that an after-combustion mostly will be reeded. The waste gases contain increasing quantities of HCl (particularly coming from PVC, . . .) with the increasing percentage of plastics contained in the domestic waste. Of importance however is the low nitrogen oxide percentage in the smoke gases of all combustion furnaces (20-150 ppm).

The transporting, storing, and manufacturing of bulk goods always go together with a development of dust. This occurs in great measure with the breaking, grinding, mixing, burning of ores just like with the tearing apart and spinning of fibers. Chemical conversions as well as casting, smelting, forging, still cause moreover a gas evolution. The danger that similar operations cause air pollutions is of course dependent on the concentration of the dust and the harmful gases. This danger for the principal industries shall now be indicated briefly and successively.

*Petroleum refinery.* — The most important polluting emissions in petroleum refineries contain sulphur oxides, hydrocarbons, and unpleasant smelling gases. Of lesser importance are carbon monoxide, nitrogen oxides and solid particles.

By far the most important source of sulphur oxides is the combustion of fuel oil in boiler houses and power stations. One other source is the waste gas of a sulphur production installation (Claus plant). This waste gas contains 1 to 2 percent $SO_2$. The harm of $SO_2$ for the human organism is greater when it goes together with solid particles such as dust and soot..., this probably comes because $SO_2$ is oxidized to $SO_3$ in the lungs on the surface of the inhaled solid particles. In a refinery that does not work particularly to fight pollution, 60 percent of the hydrocarbon emission comes from gasoline and crude oil storage and unload- and load-activities. Open water-purification installations, regenerations of catalysts and barometric condensers also contribute to these emissions, just like chimney gases that still contain unburned hydrocarbons (10-100 mg/m$^3$). The hydrocarbons that are released in the atmosphere by a refinery contribute in general but little to noticeable air pollution. Unsaturated hydrocarbons with more than 2 C-atoms per molecule can however react under the influence of UV-rays in an extremely complicated way with $NO_2$ (or ozone). Through chain reactions then, peroxides are formed and the resulting oxidized hydrocarbons can cause eye-irritations and damage to plants. A fine mist (aerosol) is formed, from which the "Los Angeles Smog" has taken its name (in Los Angeles the smog however is due to analogous elements in the exhaust gases of cars). In the moderate northern climates the sunshine is generally insufficient to start these reactions.

The unpleasant smelling gases are mostly hydrogen sulfide and organic sulphur components; also aldehydes, organic acids . . . can contribute in modest measure to bad odors. There are of course many potential sources of these gases in a refinery. The concentrations from which gases can be already smelled are sometimes exceptionally low, e.g. 1 ppb for mercaptans.

Lesser important emissions contain solid particles and nitrogen oxides, particularly arising from heating apparatus, and CO, especially arising from regenerating catalysts.

*Chemical and related industries.* — Because of the great diversity in the chemical products, the character of the air pollution caused by this industry shall thus also strongly differ. Here comes in dust as well as gas pollution.

When grinding, storing, drying, packing of raw materials and products, dust development appears.

To the most dangerous exhaust gases belong undoubtedly the halogens chlorine and bromine. These appear in installations for the production of these halogens, in electrolysis cells for $Cl_2$- caustic production,... These gases irritate in strong measure the mucous membranes of the eyes and throat.

We report particularly as halogen compounds HCl and the fluorine derivatives. Hydrochloric acid is found in the exhaust gases of the processes that are used for its production, of the dye industries... This gas irritates the higher bronchial tubes and causes as well tooth decay. Other important industries set hydrogen fluoride (and other fluorine compounds) free. This compound is very poisonous for different plant varieties while the less phototoxic flourides produce a danger for the health of cattle fed with polluted grass or hay. This possibility appears mainly in the superphosphate industry of which the raw material, the natural phosphate, frequently contains to 6 per cent calcium fluoride, yet also in industries where $CaF_2$, flour spar as fusing agent, is used (aluminum manufacture…), in the ceramic industry (especially on account of the high temperature of the modern furnaces), in the glass and enamel manufacture,… The waste gases of similar industries shall if necessary be washed intensively with water or alkaline solutions before they may escape into the atmosphere.

Sulphur compounds are especially present in the form of $SO_2$, $SO_3$ and $H_2S$. Sulphur dioxide (and $SO_3$) arises from the roasting of sulphur-containing ores, in sulphuric acid factories, during cellulose preparation (sulphite lye)…; the symptoms of poisoning are like those of chlorine. Hydrogen sulphide is one of the most poisonous gases and comes free in the spinning baths of the viscose-industry, in coke factories,… The gas especially prevents the $O_2$-$CO_2$ exchange, through which sudden unconsciousness with death can appear. In the exhaust gases of the viscose-factories, carbon disulphide, $CS_2$, is also found. When breathed in, this gas affects the nervous system and the hormonal glands.

The nitrogen compounds must still be reported. Nitrogen oxides come free during the production of nitric acid, fertilizers, explosives, . . . They possess an irritating odor, and the morbid symptoms are analogous to those of tear gas. Ammonia comes free in the Solvay process and in some processes of the fertilizer industry.

Finally, particularly dangerous is the CO, which one finds in the waste gases of the phosphor- and carbide-preparation and also in other chemical processes. Carbon monoxide in pure state is odorless and tasteless. It possesses 300 times greater affinity for red blood cells than oxygen and so causes an interior suffocation.

*"Construction materials" industry (and coal preparation).* — When drilling, pulverizing and blasting in quarries, dangerous quantities of dust can develop. The same can be said of the storing, grinding, mixing, drying of coal and of raw materials for the glass, ceramic and cement industries or of the preparation of asphalt (the drying of the aggregates gives exhaust gases with 10 to 100 g. dust/$m^3$) or of the manufacture of asbestos (this dust even causes "asbestose," a sickness that obstructs the circulation of the blood). The burning of minerals must also be reported: examples of this are the shaft- and rotating-furnaces for dolomite wherein a special fine dust with concentration of 10 to 20 g/$m^3$ develops, the furnace for the burning of limestone (15

g/m³), of bauxite, of kiezelpuhr, and of gypsum. Finally, the revolving cement kiln is certainly the chief source of dust in this industry. The harmful gases of the glass and ceramic industries were already discussed previously.

*Ferrous metallurgy.* — There are different sources of dust, tar mist and harmful gases in the coke factories. During the filling of the coke-oven the present gas mixture, mainly nitrogen, carbon dioxide and monoxide, is driven out. By the contact of the coal with the oven walls vapor and gases are immediately developed. These are colored on account of the presence of tar particles from yellow to brown and they also drag along coal particles. Big quantities of vapor that also drag along dust particles arise by extinguishing the coke. At the same time, processes take place during the valorization of the produced gas analogous to those of the petroleum-refinery and of the chemical industry.

Sinter installations: the iron ores must have a fixed grain size before they can be fed to the blast furnace. They are thus prepared in sieving, breaking and drying installations. The grains that are too small are sintered. By these sinter installations much dust (10-35 g/m³) comes free. They belong to the most unpleasant dust sources in the ferrous metallurgy. The waste gas contains $O_2$, $CO_2$, CO, $SO_2$ and also fluoride compounds.

Blast furnaces: the coke reduces the iron ores and herewith produce big quantities of poisonous gases (especially due to great concentrations of CO), loaded with much dust (10-50 g/m³). However, since the furnace gas can already be employed as fuel (1000 kcal/Nm³), one shall attempt to recuperate it completely and to submit it to a thorough removal of the dust. Gases and vapors that drag along much dust also arise by the cooling of the slags with the help of cold air.

The iron, produced in the furnace, is either cast in molds for the foundries or transported to steel-producing furnaces in the molten state.

In foundries, the cupolas are the principal source of air pollution. The escaping gas is rich with CO, but this is burned, either after mixing with air in the chimney or after recuperation of the gas as preheating source of the air used in the furnace. The gas however contains high dust concentrations. The most troublesome dust in a foundry comes from the sand of the molds. By pouring the iron into the molds the water evaporates and carries along dust particles. The protection of tubes against corrosion by means of a bituminous coating is often realized by immersing in open baths (to 180°C); unpleasant tar odor and light oil fractions separate.

Formerly, air was used to transform cast iron to steel. With the introduction particularly of pure oxygen arose the problem of the so-called "brown smoke". The use of oxygen does cause a strong temperature rise and evaporation of the iron takes place. The evaporated iron is oxidized and gives in this manner a strong brown color ($Fe_2O_3$) to the exhaust gases. The particles formed in this way are extremely fine (at most 5 u). In the Siemens-Martin furnace, about half of the present fluorine is removed with the waste gases; the added fluor spar is decomposed through the water of the gas or oil-combustion into lime and hydrogen. The other half goes as calcium fluoride with the slag. In the electric furnace, fluor spar forms on the contrary little hydrogen fluoride since almost no reactive components are available.

*Non-ferrous metallurgy* : (*Al, Cu, Pb, Zn*) — Cu-, Pb-, Zn- metallurgy (and alloys). — The most used ores are sulphides that are first roasted to free the sulphur and to convert the ore to oxide. The gases that come free here thus contain much sulphur dioxide (with dust, of course). With low $SO_2$ concentration ($< 4$ percent), it is not worthwhile to convert this gas to sulphuric acid. Further, one must keep account of the forming of metal oxides and evaporated air pollutants (e.g. As) in the gases during the smelting processes that take place at a high temperature. Here follows some average figures:

## TABLE I

### SHOWING METAL OXIDES AND EVAPORATED AIR POLLUTANTS

| | Dust percent ($g/m^3$) | $SO_2$ percent |
|---|---|---|
| Cu — roaster | 15 | 2 — 8 |
| — reverberatory furnace | 4 | — |
| — converter | 12 | to 8 |
| Pb — roaster | 2 — 15 | 1.5 — 5 |
| — blast furnace | 5 — 15 | — |
| — reverberatory furnace | 3 — 20 | — |
| Zn — roaster | 10 | 4.5 — 7 |
| — retort furnace | 0.1 — 0.3 | — |

Aluminum production: There are two distinct steps to consider, namely: the preparing of aluminum oxide from bauxite and the electrolytic production of aluminum from molten aluminum oxide. In the first step, the aluminum hydroxide that is formed should be calcined: the rising gases drag along 300-400 g. dust ($Al_2O_3$)/$m^3$. Of greater importance are the gases from the electrolytic cells: together with 0.1 g. dust/m$^3$, they contain to about 0.04 g. fluorine/m$^3$. This fluorine originates from the presence of the cryolite used in the electrolysis bath. When using the Soderbergelectrode, which is baked in the electrolysis cell itself, gases analogous to those of the coal distillation also arise.

Much data of quantities of pollutants which escape into the open-air annually are not yet known. Only in some countries are data published about exhaust gases. Here are some data of the exhaust gases in the U.S. of some contaminants (1963) in million tons per year.

TABLE 2

SHOWING SOME DATA OF THE EXHAUST GASES IN THE UNITED STATES OF SOME CONTAMINANTS (1963).

| | CO | $SO_2$ | Hydro-carbons | Solid matter (dust) | $NO_x$ | Others ($Cl_2$HF, $NH_3$...) | Total |
|---|---|---|---|---|---|---|---|
| Domestic heating | 1.8 | 3.3 | 0.6 | 1.3 | 0.7 | 0.1 | 7.8 |
| Traffic | 59.5 | 0.5 | 9.5 | 1.8 | 2.9 | 0.1 | 7.3 |
| Generation of electricity | 0.6 | 10.0 | 0.1 | 2.5 | 2.3 | 0.1 | 15.6 |
| Combustion of wastes | 1.3 | 0.2 | 1.0 | 0.7 | 0.1 | 0.1 | 3.4 |
| Industry | 1.8 | 8.5 | 3.8 | 6.2 | 1.5 | 2.1 | 23.9 |
| | 65.0 | 22.5 | 15.0 | 12.5 | 7.5 | 2.5 | 125.0 |

## *Conclusion*

The fight against air pollution must be held in three domains, namely: combustion both in view of domestic heating and of energy-generation (power stations), motorized traffic, and industry.

So far as combustion is concerned in domestic heating, it is to be expected that treatment of the waste gases of the individual chimneys certainly is not economical. The switching over from solid to liquid fuels already presents certain advantages in connection with the soot-and-tar-percentage of the waste gases. The $SO_2$-percentage on the other hand can be higher in accordance with the sulphur percentage of the used fuel oil. In big agglomerations, it should be necessary for the distribution companies to impose a maximum permissible sulphur concentration (e.g. 1 percent) in the fuel oil. At the same time directions must be issued that a regular control of the heating-installations be made obligatory. When constructing new municipal centers (e.g. in Sweden) it is desirable to foresee a common heating installation for the whole, exactly as in electric power stations, so that a treatment of the waste gases can be economical. Finally, a switching over to the perfect combustion of natural gas shall give the maximum protection against air pollution.

The air pollution caused by motorized traffic must be fought through the automobile manufacturers and through the petroleum industry. The automobile construction must aim on the one hand to avoid or to hold under control all losses through evaporation and leaks, and on the other hand to improve the combustion of the fuel/air mixture, e.g. by installing a post-combustion chamber. The petroleum industry for its side must put fuels on the market wherein, on one hand, the necessary additives are added (e.g. detergents, anti-oxidants, . . .) in order to influence the operation of the engine in a favorable way, and on the other hand, no more harmful elements (e.g. lead derivatives) appear.

Finally, the industry has itself available technical means in order to fight the air pollution caused by its waste gases. The industry should be obliged to purify the waste gases of dust and harmful gases according to the best practical means which are still economical. For mist and dust removal there are already efficacious means available and one distinguishes in rising line of effectiveness but also of the cost price, the sedimentation tanks (for dust particles coarser than 50 — 100*u*), the cyclones and the single wet scrubbers (for dust particles coarser than 2 — 5*u*), the screening filters (for dust particles coarser than 0.05 — 0.1*u*), and the electroprecipitators (for dust particles coarser than 0.005 — 0.01 *u*). The removal of gaseous impurities on the contrary, even of the often occurring $SO_2$, is not yet solved in a satisfying way. Harmful gases are mostly removed through absorption in liquids or through adsorption to solid substances. The removal is however never 100 percent, or sometimes an over-carried treatment is not economical so that it is always recommended, at the same time in order to allow for possible defects in the apparatus, to build a high chimney: for the maximum concentration of expelled harmful gases that one can find aground is inversely proportional to the square of the chimney height. Chimney of 200 m. may than also not be more rare. It is at present self-evident that the factor "air pollution" must be taken into account when looking for an establishment location of an industry.

# WATER POLLUTION

## *Presentation of the Problem*

Surface waters can be strongly polluted by waste waters of domestic, industrial and agricultural nature. The problem of waste water purification shall thus be more and more prominent on account of the rising industrialization and population growth.

The chemical products present in waste water are in suspension or in solution. They can be of mineral or organic nature.

If the pollution is of *mineral* nature, it shall mostly remain existent, although one must make allowance for a sedimentation or a natural dilution that persists when the river increases in volume during its flow to the sea. In some cases a chemical reaction shall also take place between mineral elements present in the river.

However, when the river is polluted through *organic* waste water, it attempts to overcome the pollution itself chiefly by decomposition of the organic products, based on biochemical reactions under influence of micro-organisms, mainly bacteria. Some of these bacteria can live only in the presence of oxygen: this is called *aerobic* conversion whereby the organic compounds are oxidized to carbon dioxide and water. Others are active only in the absence of oxygen: this is called *anaerobic* conversion whereby different badly smelling decomposition products ($H_2S$, $CH_4$, ..) mostly form. The action of all these bacteria is strongly influenced by external conditions such as light, pH, temperature, chemical poisons. Small quantities of certain heavy metals, of chlorine, of formaldehyde and phenol, as well as U.V. light are often very effective for killing of bacteria. The best biological action occurs at a pH = 7. The temperature also plays an important role: the greatest activity of aerobic bacteria lies mainly between 15-20°C and that of the anaerobic ones around 30°C. At the same time the saturation degree of oxygen shall fall with a rising temperature so that chances for anaerobic fermentation become bigger.

When waste waters are discharged in rivers, nature itself reacts against this pollution through dilution and through progressive sedimentation of substances in suspension, as well as through conversion of substances subject to decay or oxidizable substances. In case the water takes up sufficient oxygen during the conversion this shall take place without hindrance, so no harmful rotting shall occur. The presence of oxygen is here thus of primordial interest. On the one hand, oxygen shall mainly be consumed under influence of the bacteria for the conversion, while on the other hand an oxygen feeding takes place through absorption of air: the oxygen shall dissolve faster as the saturation deficiency becomes bigger, and the turbulence higher.

The intensity of this self-purification depends of course on the temperature and the season: it is very retarded in the winter. This self-purification must naturally be used as the most valuable means for the water purification so that, in fact, the purification stations must only be considered as resources which only purifies the water as far as is necessary in order not to overload the river and in order to let the latter do the work as freely as possible.

Procedures for the investigation of sewage and similar wastes include physical, chemical, bacteriological and other biological methods of examination. Among the varied chemical tests, those for B.O.D. (Biological Oxygen Demand) and for C.O.D. (Chemical Oxygen Demand) are most significant for providing a measure of the total amount of organic polluting matter contained in the waste and for providing a basis for assessing the effect of the discharge of the waste on the oxygen balance of the natural waters receiving it.

B.O.D. (Biological Oxygen Demand): By biological oxygen demand is understood the number of milligrams of oxygen which is required for the biological decomposition of the organic matter present in one liter of water at 20°C and over a 5-day period ($\text{B.O.D.}_5^{20}$). Fundamentally, the B.O.D. is the difference in oxygen amount of a fresh sample, and that of a same sample after it has been kept during 5 days at 20°C in the absence of light. Mostly, however, the waste water is so much loaded with organic matter that the oxygen percentage is already fallen to zero long before the fifth day. Therefore, generally, the sample is diluted with a known quantity of oxygen-saturated pure water. The oxygen percentage of this mixture is determined: a part immediately after preparation, another part after storing for 5 days in the requisite way. For the rest, the dilution is chosen so that the oxygen percentage after 5 days still amounts to about 50 percent of the initial value. For this purpose it shall often be necessary beforehand to ensure greater dilutions simultaneously.

The nature of the dilution water is thus of great importance. It is mostly freshly prepared and is always roughly saturated with oxygen. It contains at the same time a sufficient quantity of buffer and feed elements for the bacteria. It is therefore attempted to ensure in the sample in an artificial way the same situation as in purification stations or rivers where the biological purification takes place.

Further, this experiment must be applied with the biggest caution because it can give erroneous results e.g. the presence of some metals (Cu, Hg, Pb), toxic with regard to bacteria even if present in very small concentrations, give much too low B.O.D. values. Other bactericides as phenols, formaldehyde, cyanides... have the same effect. In all these cases, one chooses the C.O.D. test. Likewise, the pH of the sample must first be brought beforehand to 6.5 — 8.3 by neutralization, since acidity or alkalinity have a great influence on the activity of the bacteria.

C.O.D. (Chemical Oxygen Demand) : This is the most used chemical test in order to determine the oxygen demand of a waste water. It is based on the oxidation of organic elements (and of mineral reducing substances: sulfides, sulfites, nitrites, $Fe^{++}$ ...) by potassium dichromate and sulfuric acid in the presence of mercury and silver-sulfates. The B.O.D. and the C.O.D. test supplement each other and both are mostly performed. One however prefers generally the B.O.D. determination for the closer approximation of the real conditions by which the purification takes place in practice; nevertheless, the C.O.D. test deserves the preference with the presence of toxic elements.

## *Waste Treatment Processes*

*Domestic wastes.* — The basic processes for the treatment of domestic wastes consist mainly of mechanical and of biological treatment.

Mechanical treatment is dealt with in three different ways. Screening is determined by the particle size of the suspended solids. Skimming is applicable only to suspended matter of lower density than the water. The effective particle densities may be modified by "flotation" whereby gas bubbles adhere to solids and float them to the surface. Sedimentation is applicable only to suspended matter of relative density greater than that of the water.

Biological treatment is actually the systematic use of the natural activities of living organisms: in natural environments, either in the soil or in natural bodies of water, or on the land, e.g. using grass plots; or in artificial environment, such as intermittent sand filters, septic tanks, trickling filters, activated-sludge plants.

Being the most widely used aerobic biological waste treatment systems, the trickling filter and the activated-sludge systems shall be briefly described here.

*Trickling filtration.* Purification of waste waters containing organic substances by treatment on trickling filters is a biological process depending primarily on absorption and adsorption of both soluble and suspended matter from the waste water into and onto zoogloeal slimes which develop and proliferate on the surfaces of the filtering medium over which the water trickles or flows by further complicated processes of decomposition and synthesis of both the soluble substances and sludge-forming solids. Some of the solids are thereby removed from the wastes. These decomposition and oxidation processes result from the activity of bacteria, various forms of fungi and protozoa, together with other living organisms, which feed upon them, preventing unrestrained accumulation and clogging.

Trickling filters have been adequately described as merely a pile of rocks over which sewage or organic wastes slowly trickle. A schematic cross section of a trickling filter is shown in Fig. I.

The sewage is introduced into the filter by a rotary distributor which is driven either by electric motor or by hydraulic impulse. The rotary distributor is so designed that the wastes are discharged at a uniform volume per unit of filter surface. The wastes flow by gravity over the stones and into an underdrain system. All the liquid is collected into a main effluent channel which flows to a final sedimentation tank.

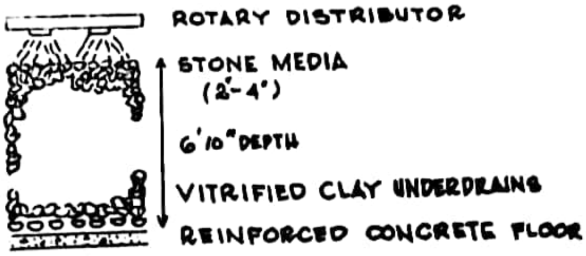

FIGURE I — SHOWING SCHEMATIC CROSS SECTION OF A TRICKLING FILTER.

The depth of rock in the filter varies from a minimum of 1 m to a maximum of 3 to 5 m, with an average stone depth of 2 m. The size of the rock ranges from 3 to 10 cm in diameter and the rocks are carefully selected for their spherical shape. Flat stones tend to compact too tightly and reduce the essential void volumes. The choice of the filter-stone size will be dependent upon the waste characteristics. With a high organic load per unit volume of filter it is essential to have large stones if the biological growth is not to fill all the voids and clog the filter.

The underdrain system is normally vitrified-clayblock construction. In effect the underdrain system is a network of tiny channels which rapidly discharge their flow into the main collection channel which normally runs along the middle of the filter. An equally important function of the underdrain system is to allow sufficient air to circulate through the filter.

The final sedimentation tank has the function of removing the large masses of biological growths which have dropped from the filter stones.

The schematic diagram of the trickling filter system is shown in Fig. II.

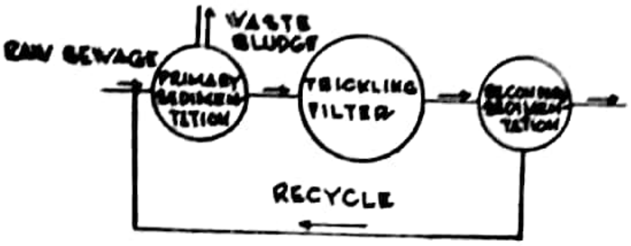

FIGURE II — SCHEMATIC DIAGRAM OF A SINGLE-STAGE TRICKLING FILTER.

*Activated-sludge treatment.* — This is a treatment also by biological processes which is similar to that of trickling filtration, likewise depending upon adsorption into active zoogloeal slimes, and is basically different only in that no medium is used to support the zoogloeal slime. The sludge particles from sewage is activated by aeration so as to develop an active culture of aerobic organisms, in this case carried by the particles. By accumulating and circulating a sufficiently large quantity of activated sludge, contact treatment of sewage is possible, and its rapid purification is ensured accordingly.

A schematic diagram of the basic process is shown in Fig. III.

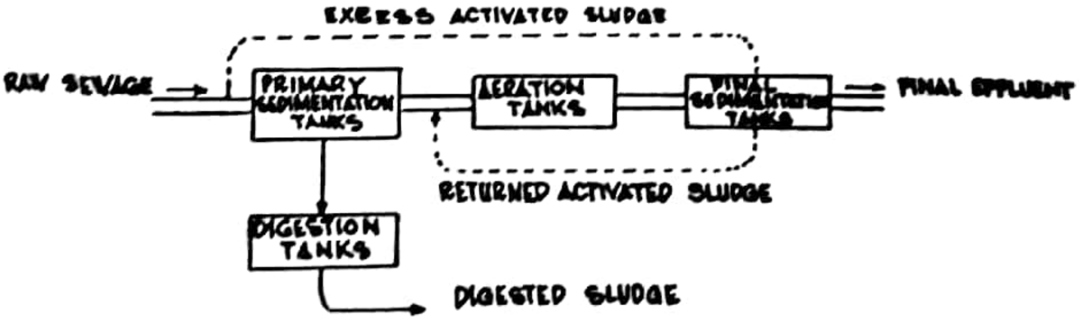

FIGURE III — SHOWING FLOW DIAGRAM OF ACTIVATED-SLUDGE PROCESS

A normal arrangement provides first for plain sedimentation of the waste, with the object of removing the coarser suspended matter with as much of the finer solids as feasible, using detention periods of at least 2 h for municipal sewage; the settled waste is then mixed with the returned activated sludge and the mixture discharged directly into the forward end of the aeration tanks. The various systems of aeration tanks require aeration periods of 1 — 10 hrs. or more; the actual period depends on the system used and the strength of the waste to be treated but should be adjusted to effect the required degree of purification and, at the same time, to keep the sludge "alive" or activated. The effluent purified waste and activated-sludge mixture is then treated by sedimentation in final tanks, from which the sludge is returned while the overflow of purified effluent is ready for disposal or further treatment. Excess sludge is taken from the returned sludge regularly and usually treated by digestion along with the raw sludge from the primary sedimentation tanks before final disposal.

*Industrial waste water.* — Industrial waste water shall be discharged as much as possible in the sewers in order to be purified as well in the municipal purification station. Naturally, one has to eliminate beforehand the products which can be recuperated economically or those which can damage the good operation of the purification station (poisons...). Further, it must be looked for that the temperature of the waste water does not exceed 35°C and that the pH is neutral.

In many cases, however, the municipal purification station is not designed for the decomposition of industrial waste waters, or it cannot treat very big flow rates (mineral industries, paper factories, sugar factories...), or there exists simply no municipal purification station. Separate purification stations must then be established. One makes difference among the waste waters discharged by organic, mineral and mixed industries. In this last case, one must use a series of techniques.

*Organic Industries.* — Wastes of organic industries can be treated by the method explained for the purification of domestic waste water. Sometimes, however, adjustments are necessary on account of the very high concentrations of the polluting substances. A dilution or pretreatment (lagoons...) can be provided to bring back the B.O.D. of the water to values (1000 — 1200 mg/l) that allow a treatment in trickling filters or with activated sludge. One can also get the same effect through pre-aeration.

The biological activity is sometimes prevented by the fact that the organic material that has to be used as food for the bacteria has a too-uniform character. Sometimes then, city water as well as fertilizers must be added.

*Mineral Industries.* — Industries that deal with pure mineral matter in suspension and/or in solution can not be biologically purified. In its place, a chemical treatment must be applied.

The removal of the solids in suspension occurs in a way analogous to that used for the organic industries: by sedimentation.

The dissolved mineral matter shall either be precipitated or will be converted to harmless products (through neutralization, oxidation-reduction...). In the first case, one should add a predetermined precipitating reagent, after which a sedimentation is applied. Strongly acidic or basic waste waters before discharging into the river, shall be generally neutralized by addition of an adequate dose of alkaline (e.g. lime) or acid (e.g. sulfuric acid, smoke gases) reagents respectively.

A particular problem is posed by radio-active waste waters. The radio-active matter can be removed, among others, by ion-exchangers or by evaporation. The exhausted ion-exchangers, as well as the residue of evaporation, are then incinerated and enclosed in concrete vessels, and finally brought into the sea or in abandoned mines.

# MAPLIN — SEA AND AIR HUB OF TOMORROW

by

IAN M. BAKER[1]

The tidal Maplin Sands in the outer estuary waters of the River Thames will soon emerge as the site of the biggest engineering project Britain has seen this century.

The result over the next eight years will be a massive sea and air transport complex with a particular part to play in Britain's European role.

From the early 1960s investigations were carried out by the Port of London Authority into possible estuary development and in 1964 a Bill was put through Parliament extending the seaward limit of the Port of London further out into the estuary and encompassing the Foulness-Maplin area. This gave the Port of London Authority (PLA) control over 92 miles (148 kms. of the tidal Thames, from Teddington (the inland tidal limit) to the Tongue lightship on the edge of the English Channel.

The first result of this extended authority was to allow the PLA to dredge a new entrance channel for tankers and to install the most sophisticated radar and tide reading equipment.

## CONSORTIUM'S ROLE

In 1969 the PLA, with other interested parties, formed a consortium to investigate the feasibility of Maplin. As part of this consortium and on its own account the Authority spent some £500,000 on hydraulic and economic research into the Maplin idea.

At the same time the Government was looking for a site for the third London airport. From a short list of sites, Maplin the only one on the list not inland nor on existing land was chosen.

In February this year (1972) the Government asked the PLA to submit its plans for seaport oil and container terminals. At the same time it ruled out major industrial development at Maplin, including oil refineries, steel mills and petro chemical works.

## PUBLIC MONEY PREDOMINATED

This type of airport — seaport industrial scheme, designed to match Rotterdam's Europort, had been urged by the many organiza-

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[1] An official of a major harbor authority.

tions actively promoting and bidding for the project. The Government however has indicated that it will be in the country's interest to involve a majority of public rather than private money.

The ruling out of heavy industry at Maplin in no way negated or even weakened the basic concept for an air and sea port. There is already massive industrial investment in the Thames corridor.

The February statement by the Government was greeted by the PLA Director General, Mr. John Lunch, as a green light and a stimulus for further planning. Within six weeks the detailed PLA scheme for the new channel, reclamation and oil and container berth development were submitted to the National Ports Council.

The Council act as advisers to Government on all port matters and administers the Harbors Act under which permission can be given for major port development projects.

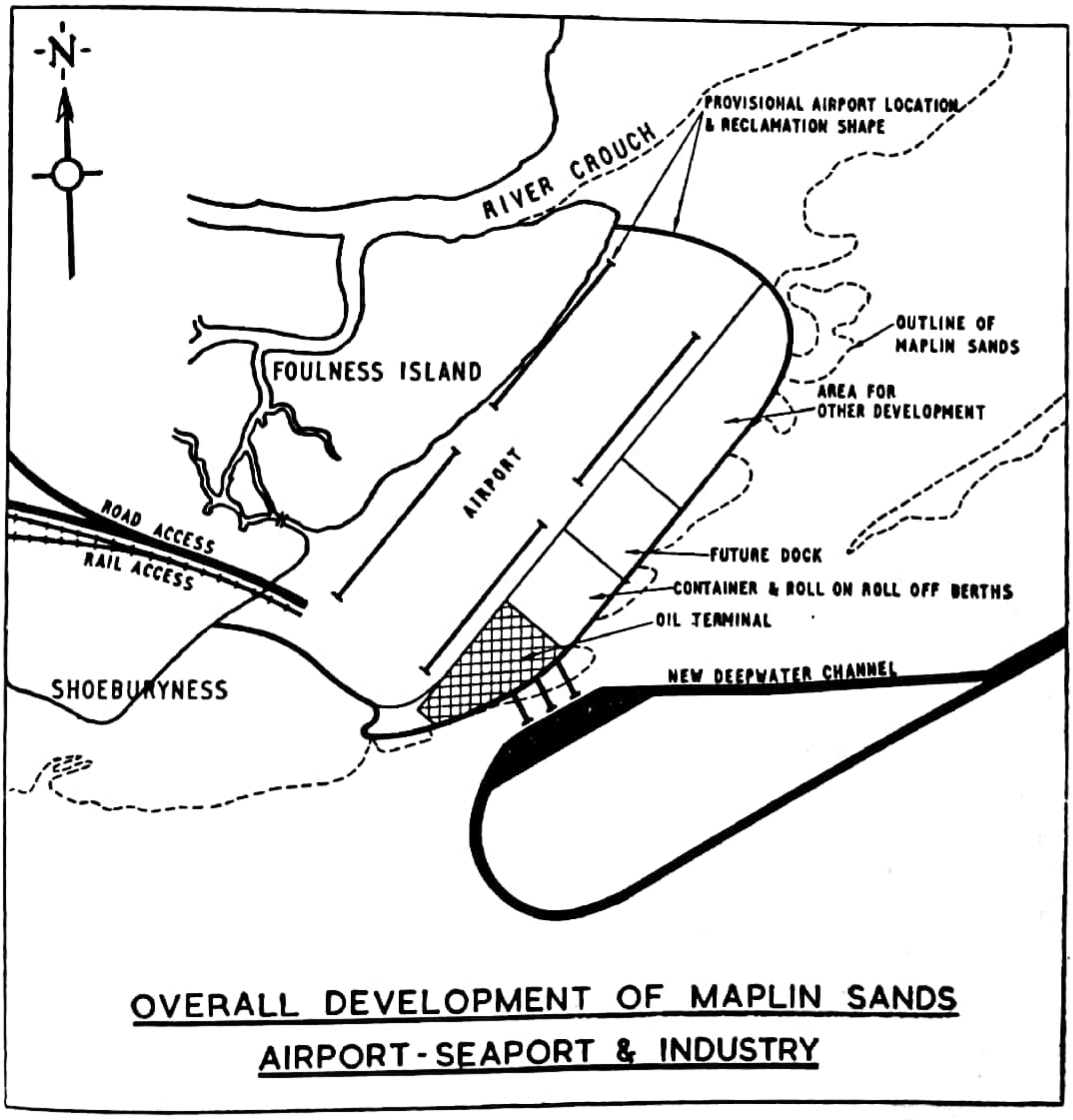

FIGURE I — THE TIDAL MAPLIN SANDS IN THE OUTER ESTUARY WATERS OF THE RIVER THAMES.

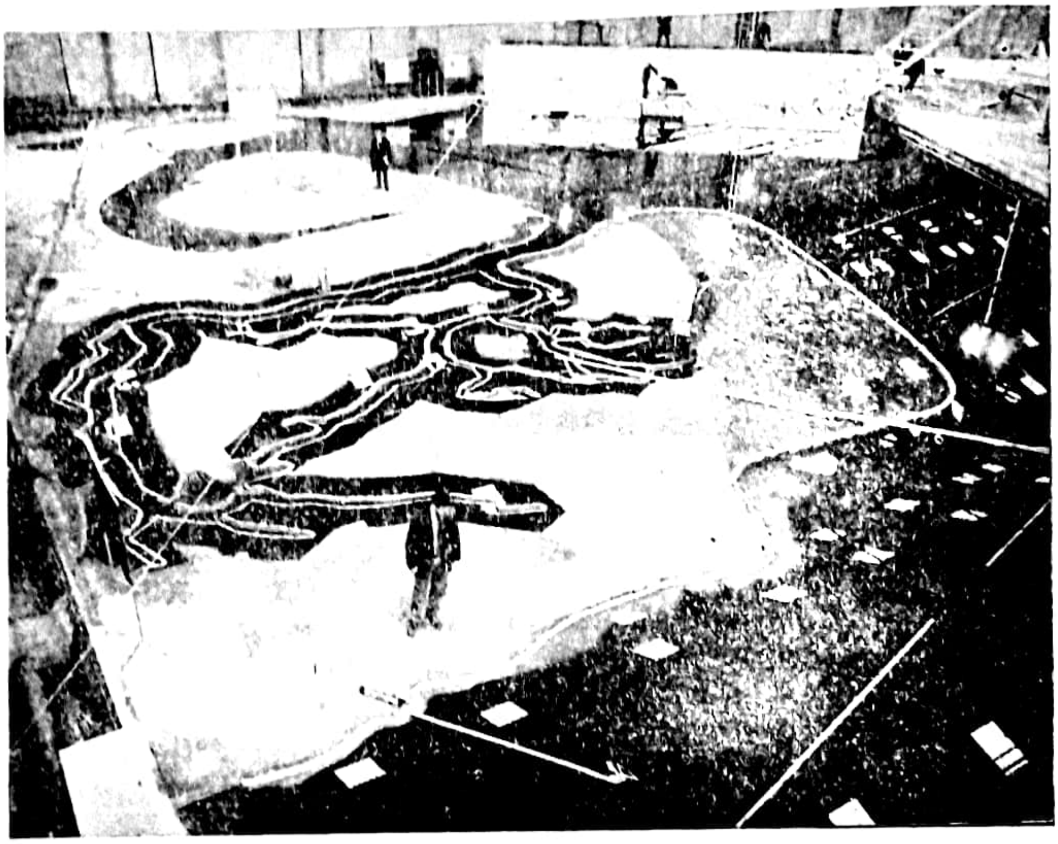

FIGURE II — THIS MAP SHOWS THE LOCATION OF MAPLIN SEA PORT IN EASTERN ENGLAND.

## THE FIRST STAGE

On 26 April the Government gave agreement in principle for the first stage — the dredging of the deep sea approach route, land reclamation and the building of an oil terminal. This agreement has enabled the PLA to proceed with commercial negotiations and justification, essential for the final Harbors Act authorization.

A new section within the PLA was headed by Mr. John Black, formerly Chief Planner.

The proposed oil terminal will be at Blacktail Spit on the edge of the reclaimed area. It will involve an initial reclamation of 300 acres (121 hectares) rising in stages to the required 1,000 acres (404 hectares). The reclamation spoil will come from dredging the new deepwater approach channel.

## ONE LONG TUNNEL

The first stage of channel dredging will be designed for tankers of 65 feet (20 m) draught, representing a vessel of 250,000 deadweight tons, fully laden.

The Channel will be 34 miles (55 kms.) long and stretch from the Long Sand Head to Maplin. There are already many natural deeps in the estuary and this first stage dredging will basically join these together into one long channel. It will be 1,000 feet (305 m) wide for the first six miles and 600 feet (183 m) for the remaining 28 miles (45 kms.). For the 65 feet (20 m) draught vessels there will be an average underkeel clearance of between three and five feet (to 1.5 m).

Stage Two is already planned and this will involve deepening to accommodate 85 feet (26 m) draught vessels, representing a fully laden 500,000 tonner — the largest likely to be visiting north west Europe.

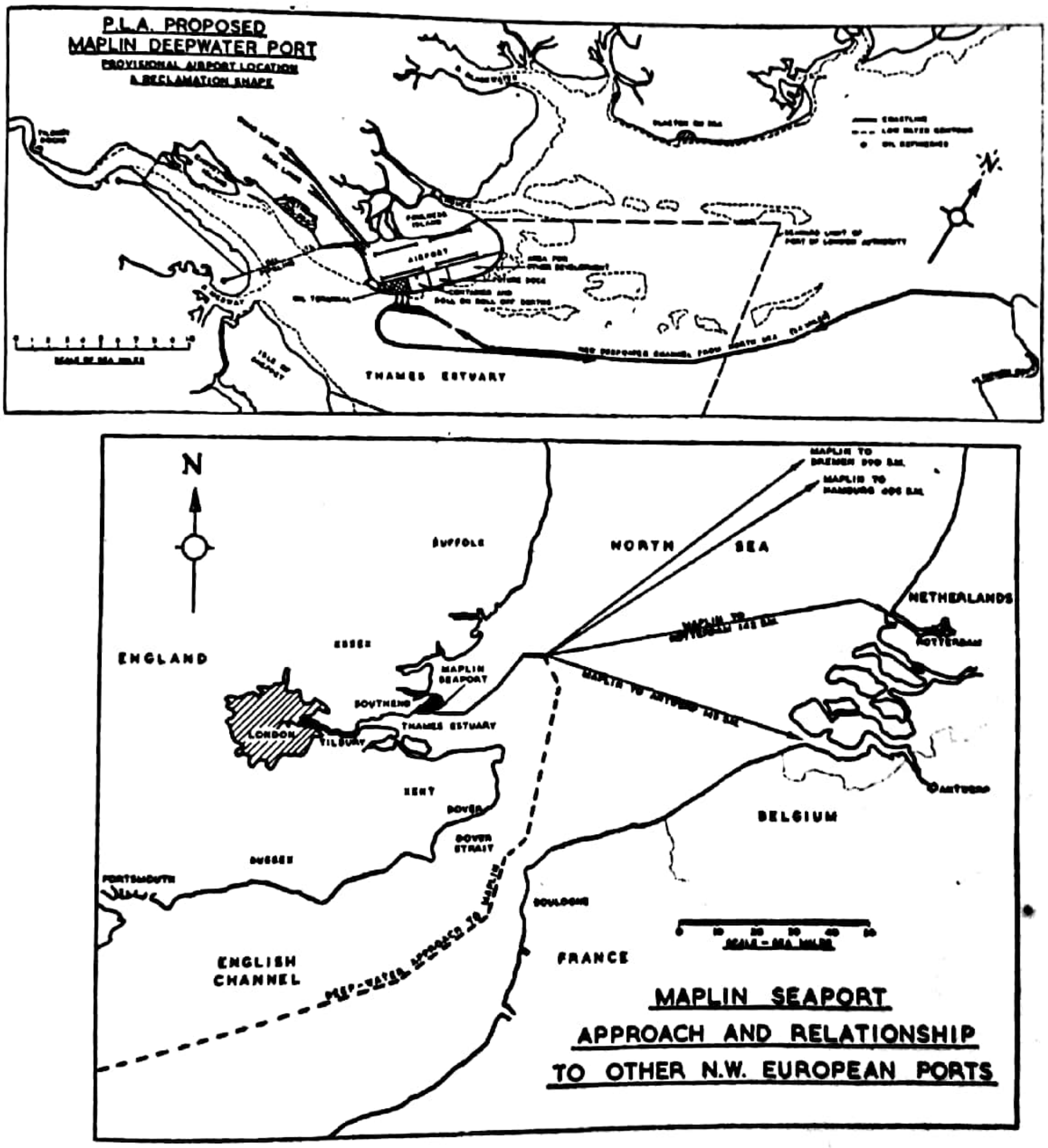

FIGURE III — SHOWS TWO WORKING MODELS OF THE THAMES ESTUARY AND MAPLIN SANDS.

The first stage of Maplin will cost in the region of £35 million and will be completed by 1976. The oil terminal will include a conventional T-head jetty, equipped with modern pumping units capable of discharging crude oil at a rate of 4,400,000 gallons (20,000 $m^3$) per hour.

The throughout of the new terminal will be between 23 and 30 million tons in the first year or so, doubling in 10 years.

The PLA is also hoping for further approval for its planned container and unit load cargo berths at Maplin.

## TOO LARGE FOR TILBURY

London through its docks at Tilbury is already Britain's leading container port. But it was soon realized that third and fourth generation container ships would be too large for Tilbury.

Maplin plans involve berths from 50 to 100 acres (20 to 40 hectares) in area, compared with the average 20 acres (8 hectares) at Tilbury, modern handling equipment and very deep water berths.

## UNITIZED TRAFFIC BENEFIT

Two container berths are envisaged in the early stages with plans for further installations.

Maplin has a very significant role to play in Britain's European context. It will serve the trade needs between Britain and Continental Europe, while maintaining competition with near Continental ports for Europe's trade with the rest of the world.

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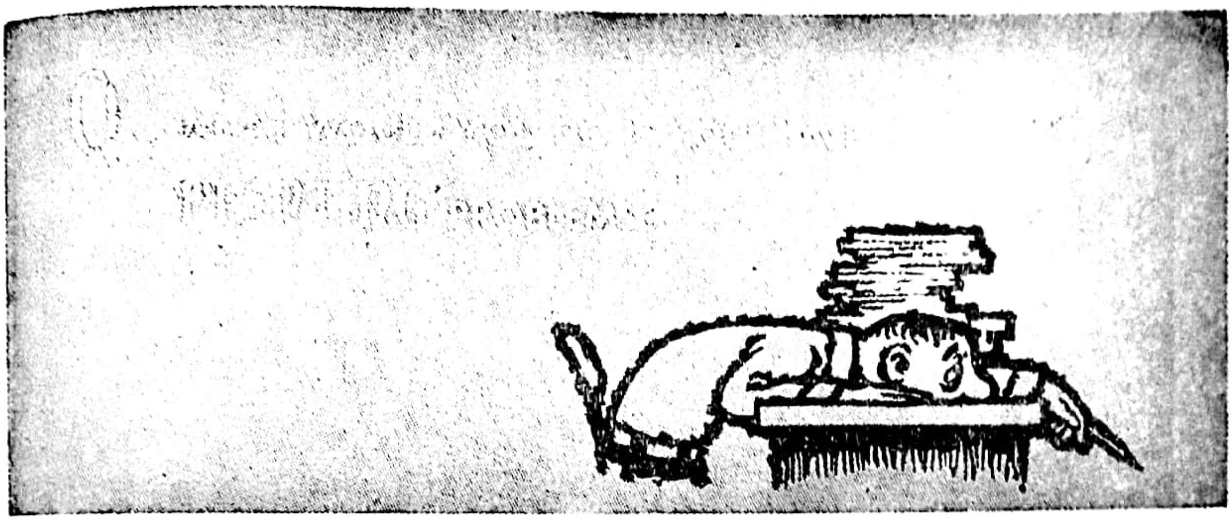
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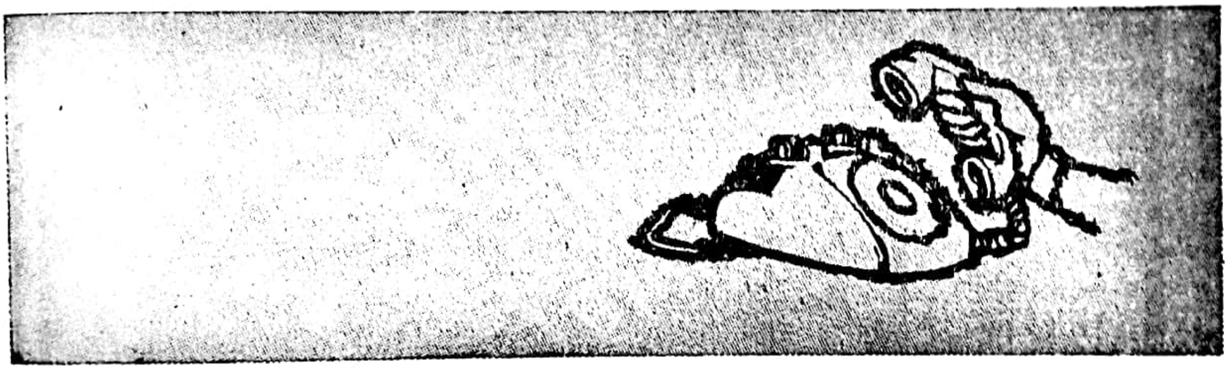

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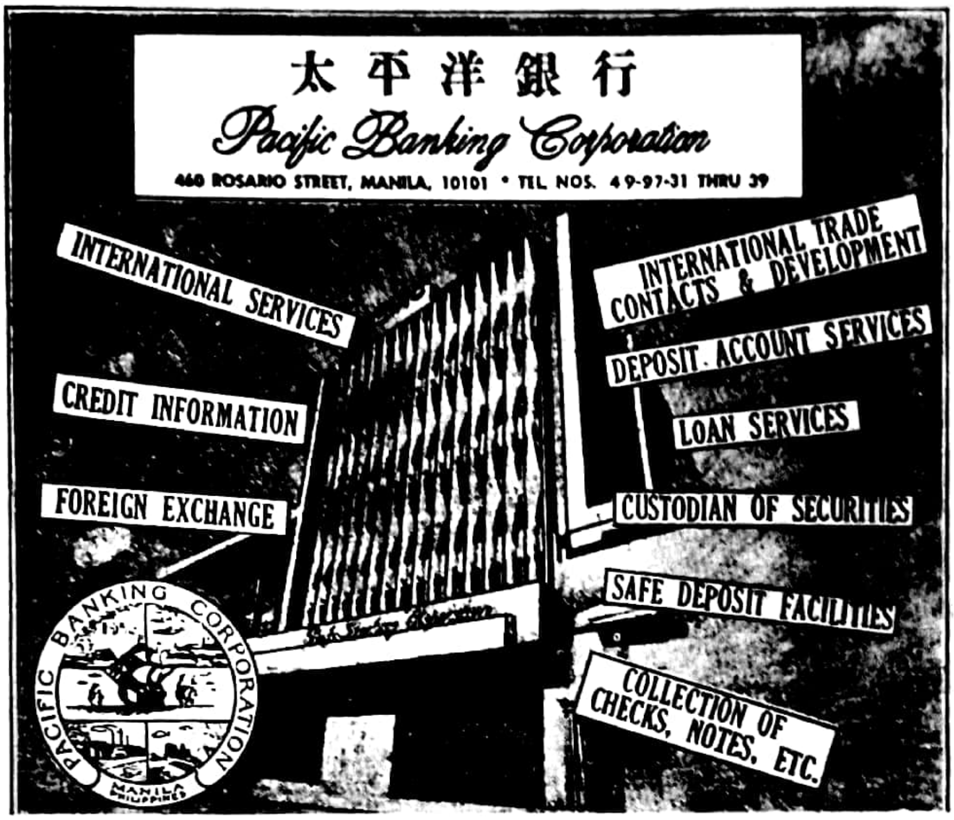
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