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ABSTRACT.

INTRODUCTORY NOTES ON GERMAN NAVAL INFRA-RED COMMUNICATION EQUIPMENT.

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SUMMARY: It is explained that infra-red waves, on account of their limited range, ease of beaming and security against unwanted interception, represent an important addition to the range of waves so far applied to short range point-to-point communication links.

The dependence of range on weather conditions, time of day, height of stations, transmitter power and receiver sensitivity is explained. It is shown that the range is greatest on clear dark nights, and is lower in day time because of the influence of visible light, that transmission through fog is improbable and that the range is strongly dependent on the height of the stations because of the rectilinear propagation.

The generation and reception of infra-red radiation is discussed and a description is included of the most important equipment (Seehund) and its chief applications. Any sort of lamp can be used as a source but for reception photo-electric cells or light-sensitive screens are needed. The Seehund equipment is seen to be suitable for horse traffic.

Other infra-red equipment is mentioned but is not described in detail, either because it is not yet in service or because it does not come into the field of Naval communications."

1. Reasons for Choice of Wave-band.

The importance of security is emphasised and the danger of interception of short wave or decimetre transmission is pointed out. The advantages of infra-red radiation are that it is not immediately observable, can be sharply beamed and is strictly limited in range.

2. Physical Fundamentals.

Generation, propagation and reception are discussed. Generation and reception depend on the state of development of the equipment but propagation is fixed by known physical factors.

(a) Propagation. The nature of infra-red waves is explained and the variation of sensitivity of the eye with time of day is pointed out (Fig.1). In free space propagation is rectilinear but in practice it is dependent on the state of the atmosphere. The only phenomena caused serious bending at infra-red frequencies are inversion phenomena such as Fata Morgana. The effect of atmospheric absorption is strong:- "In the infra-red region the water vapour content plays a predominating role. In transmission through the atmosphere the ratio of drop size to wave length is of great importance and it is therefore possible with infra-red to penetrate haze which absorbs visible light. It is nevertheless still impossible to penetrate fog. The atmospheric transmission co-efficient varies greatly over the infra-red part of the spectrum as can be seen from Fig.2."

(b) Production and reception of infra-red radiation. Any source of light can be used as an infra-red transmitter if fitted with filters to cut off visible light.(Fig.3) In general, the optical signal lamps already available are used. For infra-red telephony special high-

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pressure mercury vapour searchlights are used in which the line spectrum is spread into a continuous spectrum. Carbon arcs are unsuitable because of noise.

For reception thermocouples and photo-cells are necessary:- "Photo-cells are films from which electrons are released by the impact of light waves. This can take place either on the surface or within the material; these processes are called respectively the outer and inner photo-effects. Photo-cells can be made in either gas filled or evacuated bulbs (gas filled and vacuum photo-cells).

Alkali cells use the outer photo-effect; the best known example is the Caesium cell. This is used in image-formation to produce electrons which, when released from the light-sensitive sheet by infra-red radiation, are accelerated by the high voltage and focused so as to produce an image of the light source on a phosphorescent screen (optical presentation).

Photo-voltaic and photo-conductive cells depend on the inner photo-effect. Photo-voltaic cells develop a voltage on the impact of light waves. The best known of these so called "Boundary Layer Cells" is the Lead Sulphide (PbS) cell. In the visible region copper oxide (Cu, CuO_2) is used. Photo-conductors alter in resistance on the impact of light, and an auxiliary voltage is necessary when they are used. The selenium cell is the best known example. In addition, Thallium Sulphide (TlS) cells and synthetic lead sulphide cells are used.

To increase the sensitivity the cell is placed at the focus of a paraboloid. The mirror is not silvered but rhodium plated and is therefore less susceptible to mechanical and chemical action. Behind the cell there is a low frequency amplifier which amplifies the signals till they are audible (audio presentation).

While cells based on the inner photo-effect only react to differences of light intensity, alkali cells are very sensitive to steady illumination. However, as they are insufficiently sensitive in the infra-red region by comparison with the visible, they are not suitable for communications. To increase the infra-red sensitivity compound films are used in place of pure selenium.

In contrast to HF practice in which a fixed carrier frequency is used, it is here necessary to radiate a wide band of frequencies. This is because there is no frequency in the infra-red region which is at once the best for generation, propagation and reception. The band used is bounded on the short wavelength side by the filter cut-off and on the long side by the characteristics of the photo-cell (Fig.4) and the light source (Fig.5)."

3. Description of Equipments already in Operational Use.

"Seehund" is an infra-red telescope for Morse traffic reception (Figs. 6 and 7) and can be used to read signals from Morse lamps, keyed searchlights etc.

"In the Seehund the light waves are focused by a lens on to a vacuum photo-cell, from whose cathode electrons are released which are accelerated by a high voltage and focused with an electron lens on a phosphorescent screen. Behind the screen there is an optical system magnifying the image fourfold. The Seehund must be protected from high temperatures, and exposure to direct sunlight must be avoided as it will destroy the photo-sensitive surface...Another infra-red aid to communications is the Lenard-Phosphor which can be used as a very simplified Seehund. Its chief use is to observe whether another station is radiating infra-red towards one."

Fig.8 shows the optical system of the signalling lamp and Fig.9 its polar diagram.

4. Equipments under Development.

"The equipments described so far are only suitable for large units on account of their size. As lighter craft also need it, a small equipment is in development. This is primarily a smaller version of the Seehund and is simply scaled down (Seehund 3). The development and manufacture of equipment for

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infra-red telephony has been delayed by other high priority work so it need not be described here. Further developments will be reported in this Journal in due course."

5. Other Infra-Red Apparatus.

Infra-red can be used for burglar alarms, vehicle counters and for observation of thermal radiation from ships' funnels, or rays from light-sources shielded against visible radiation. The Naval equipment known as "Igel" is an improved Seehund using two high voltage leads so that the two H.T.voltages can be adjusted separately. This set is used as an aid to gun-laying (für artilleristische Zwecke). "These applications, however, do not come under the heading of Naval Communications and cannot be discussed further here."

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