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64-7

FINAL REPORT

DETECTION OF HUMANS IN CONCEALED PREPARED POSITIONS

Prepared for
Limited War Laboratory
Aberdeen Proving Ground

THE BIOSEARCH COMPANY
BOSTON, MASSACHUSETTS

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OUTLINE OF CONTENTS

A. PREFACE

This report was prepared in accordance with the requirements of United States Army Contract DA-019-AMC-0122-R, and with the approval of the U.S. Army Limited War Laboratories, Aberdeen. Md.

Dr. Max Krauss, Chief of Biological Research at the Limited War Laboratories, has been the Technical Project Monitor for this work. Mr. Stephan Fedak, Deputy Chief, R&D Branch, Boston Army Procurement District, was the Contracting Officer's Representative and also provided liaison with the Army Procurement Office at Aberdeen, Md.

The technical analyses were done by an interdisciplinary group, with participants in physics, chemistry, biology, medicine, biophysics, and various engineering disciplines. This report was written by Dr. Alfred T. Kornfield.

Grateful acknowledgment is expressed for the special assistance provided by Mr. Fedak and the Boston Procurement District staff, for the technical counsel and aid of Dr. Krauss and personnel at the Limited War Laboratories, and to all of the Biosearch Co. professional and technical personnel who contributed so ably to this report.

THE BIOSEARCH CO. BOSTON.

Dr. A. T. Kornfield, President.

B. INTRODUCTION

To examine the capabilities of biosensing techniques for the detection of humans in concealed positions, this study concerned itself with a review of the diverse attributes of man yielding signals, the signal modifications in environment, and various sensing concepts.

About 2000 references are cited, selected from an aggregate of about 8000 with the balance rejected as irrelevant or of no value. Resources used included over 30 document and book collections; the Harvard Libraries (the medical and Cambridge complexes); MIT group; Boston Medical; Boston Public; Boston Univ; Tufts Medical; New York Public; ASTIA(DDC) reprints and their NY regional center film collection; QMR&E Library, Natick; Army Chemical Lab Library, Edgewood; Air Force Cambridge Res Lab. Library.

In considering human signal sources and attributes, emphasis was placed on assembly of a catalog of chemical substances excreted through all body portals; for comparative analysis, other human physical attributes and signals were set down (emission, reflection, proximity properties), resulting in an inventory of most of the major signals produced by man

Environmental modification of chemical signals from man, by substances from plants and animals, weather effects, etc; was augmented also by comparative data on effects of environment on physical signal transmission.

Sensing techniques examined highlight biosensing (defined as the use of living material as transducer or pickup, in isolated form, for chemical or physical signals, analogous with physical sensor devices. A large aggregrate of possibilities is presented for consideration, emphasizing chemosensing, which offers the most potential of all of the biosensors for the major problem solution. The plausibility of the biosensing concept must rest on evidence presented, of ability to maintain material alive, to conveniently gather reproducible input/output data from it, and to find performance properties superior to physical or chemical sensing. Comparative data on chemical and physical sensing of chemical substances and physical phenomena is presented.

From the short effort completed, three things have resulted. One is this report, serving as a source book, aiding the reader in going further in exploring in depth any concept cited, and in further analysis of complete detection systems of biological, chemical, or physical nature, as grounded in known human properties. The second result is the series of recommendations for further work, based on the findings in the study, suggesting experiments on promising techniques, particularly on biosensing, also reviews and analyses to make up for data deficiencies uncovered in the literature. The third result is the provision of an "idea" book here, with a variety of speculative possibilities presented, for detection, but set off clearly from those documented concepts stated.

Pursuit of a more thorough analysis across the span of all of the areas presented would be desirable, highlighting the promising areas set forth in the recommendations; this could aid in bringing the Limited War Laboratory effort more rapidly towards the goal of a suitable field detection instrument for concealed humans.

C. HUMAN ATTRIBUTES AND CONTRASTS

I. Chemical Products.

On the following pages will be found a list of major chemical substances excreted in urine, in feces, and from the skin. These are readily traceable to sources of quantitative data for each substance, permitting the reader to go further in analysis of detection of concealed humans by chemical products emitted.

In addition to the list, supplementary data and comments follow, on skin products(sweat, sebum, etc.), their alteration by skin bacterial action, the attraction of animals by their odors; also provided are additional data on urine products, g.i. tract excretions, and expired air.

Ethnic and regional comparisons of these products are presented, and regional diet and nutritional data source information is cited. Notes on related closed-cabin-ecology studies and on human tissue chemical composition are given.

a. List of Major Chemical Substances Produced by Man..

The tables which follow have the following features: the first section lists over 400 specific chemical substances of low molecular weight, produced as indicated from one or several of the three body channels as feces, urine, or skin products(from eccrine, apocrine, sebaceous glands, etc.). The short second section contains a mixed collection of hormones, enzymes, other high molecular weight substances, etc. The third section lists the references from which can be obtained quantitative data on each substance measured, from the body channel indicated.

To Use the Tables:

Note that each specific chemical name is accompanied by symbols indicating the body excretory channel, and reference codes to be looked up in the reference list in the third section.

Example: Alanine, total. . . . . . S-AG, U-12HBU.(taken from Table).
S-AG= Sweat or Skin, (in reference AG).
U-12HBU=Urine, (in references 1, 2, H, B, U).
Turn to third section of table, note that code AG cites page 223 of (Kuno-56)listed in biblio at end of report; #1 cites page 363 of (Altman-61), etc.

CHEMICAL SUBSTANCES EXCRETED BY MAN

Section 1. Specific Substances of Low Molecular Weight

ACETIC ACID	S-AC,
ACETOACETIC ACID	U-12
ACETONE FREE	U-12E
ACONITIC ACID	U-2
ADENINE	U-12
ADIPIC ACID	U-2
ADIPIC ACID ALPHA AMINO	U-2
ADRENALIN	U-2B
ALANINE CONJUGATED	U-2
ALANINE TOTAL	S-AG, U-12HBU
ALANINE BETA	U-2U
ALDOSTERONE	U-1
ALLANTOIN	U-12BHJ,AA,AC
ALUMINUM	F-5Y U-12FH,AC
AMINES PRIMARY	U-2
AMINES AROMATIC FRACTION	U-2
AMINO ACIDS FREE	U-AA,AC
AMINO ACIDS TOTAL	S-6BKLSTV,AG U-1BHJ,AA
AMINOLEVULIC ACID	U-H
AMINO SUGARS	U-H
AMMONIA	S-67BLTV,AG F-5BFZ U-12BFH,AA,AC
ANDROGENS MALE	U-1
ANDROGENS FEMALE	U-1
ANDROSTERONE	U-1
ANSERINE	U-2
ANTHRANILIC ACID	U-2
ARABINOSE	U-2
ARGININE FREE	U-BH
ARGININE COMBINED	U-2B
ARGININE TOTAL	S-6BL,AG F-5BR U-12BHU,AB,AC
ARSENIC	S-F F-5AF U-1F
ASCORBIC ACID	S-6DLV,AE,AG F-5D U-12D,AC
ASCORBIC ACID DEHYDRO	S-3,AG U-2
ASPARAGINE	U-2U
ASPARTIC ACID FREE	U-1BH
ASPARTIC ACID COMBINED	U-2B
ASPARTIC ACID TOTAL	S-AG U-12BHU,AB
BENZOIC ACID, PARA-AMINO	S-3LD,AG F-59D U-125D
BENZOIC ACID, META-HYDROXY	U-2
BENZOIC ACID, PARA-HYDROXY	U-2
BENZOIC ACID THREE-METHOXY-FOUR-HYDROXY	U-2
BERYLLIUM	U-2
BICARBONATE	U-2
BILIRUBIN	S-E U-15EH
BIOTIN	S-6DL F-9DS U-12D,AC
BISMUTH	S-V
BROMINE	S-V,AG U-12F
BUTYRIC ACID, ALPHA-AMINO	U-2
BUTYRIC ACID, AMINO	U-U
BUTYRIC ACID, AMINO-ISO	U-2
CALCIUM	S-67FLTSV,AG F-5AGXZ U-125FHJX,AC
CAPROIC ACID	S-AE,
CAPROIC ACID, ALPHA-KETO-ISO	U-2

CAPRYLIC ACID	S-AE,
CARBONIC ACID	F-NW U-1
CARBOXAMIDE, N-METHYL-TWO-PYRIDONE-FIVE-	U-2
CARNATINE	U2
CARNOSINE	U-2
CAROTENES	F-5D U-5
CATECHOLAMINES	U-2
CATHEPSIN	U-2
CHLORIDE	S-67FLS,AG F-5AFGXZ U-12FHJX,AC
CHOLESTEROL TOTAL	S-4CKMST,AG F-5C U-12CH,AC
CHOLESTEROL DEHYDRO	S-4
CHOLESTEROL ESTERS	S-4,AG
CHOLINE	S-6DLTV U-12DH,AC
CINNAMIC ACID, PARA-HYDROXY-	U-2
CINNAMIC ACID THREE-METHOXY-FOUR-HYDROXY	U-2
CINNAMOYL-GLYCINE, PARA-HYDROXY-	U-2
CITRIC ACID	S-AE, U-12EH,AC
CITRULLINE FREE	U-5B
CITRULLINE COMBINED	U-B
CITRULLINE TOTAL	U-125BV
COBALAMIN	U-1D
COBALT	F-5F U-2FS
COPPER	S-37TV,AG F-5AFY U-125FH,AC
COPROPORPHYRINS	U-1EH
CORTICOIDS	S-3
CREATINE	S-L,AG U-12BH,AC
CREATININE	S-37BKLSTV,AG U-12BHJ,AA,AC
CRESOL,PARA	F-R U-2
CYSTEINE	U-U
CYSTINE FREE	U-1BH
CYSTINE COMBINED	U-2B
CYSTINE TOTAL	S-AG, U-12BHU,AB,AC
DIKETOGLUCONIC ACID	U-12
ERGOTHIONINE	U-2
ERGOTHIONINE, CONJUGATED	U-2
ESTRADIOL	U-12
ESTRIOL	U-1
ESTRONE	U-12
ETHANOLAMINE	U-2H
FAT NEUTRAL	F-5CZ
FAT UNSAPONIFIABLE	F-5C
FAT TOTAL	S-AG, F-5ACGZ
FATTY ACIDS FREE	S-48CS F-5CGZ,AF U-H
FATTY ACIDS HYDROXY	S-8
FATTY ACIDS UNSATURATED	S-C
FATTY ACID ESTERS	S-TK
FATTY ACIDS COMBINED TOTAL	S-M F-G,AF
FATTY ACIDS TOTAL	S-8T F-5C
FERULIC ACID	U-2
FERULIC ACID, DIHYDRO	U-2
FLAVINES	U-2
FRUCTOSE	U-2
FOLIC ACID GROUP	S-3DLTV F-59D U-12D,AC
FORMIC ACID	U-12E
FLUORINE	S-V U-12F,AC

GALACTOSE	U-2
GLUCOSE	S-37EKSTV,AG U-25EH
GLUCURONIC ACID	U-2H
GLUTAMINE	S-AG, U-2HU
GLUTAMINE, PHENYLACETYL-	U-2
GLUTAMIC ACID, FREE	U-1BH
GLUTAMIC ACID COMBINED	U-2B
GLUTAMIC ACID TOTAL	S-AG, U-12BH,AB
GLUTARIC ACID	U-2
GLUTARIC ACID, ALPHA-OXO-	U-2
GLYCERIC ACID	U-2
GLYCERIMIDES	U-AD,
GLYCINE FREE	U-125BHU
GLYCINE TOTAL	S-AG, U-15BH
GLYCOCYAMINE	U-2,AA
GLYCOLLIC ACID	U-2
GLYOXYLIC ACID	U-2
GUANIDINE	U-H
GUANIDINOACETIF ACID	U-1H
GUANINE	U-12
GUANINE, N-METHYL-	U-12
GUANINE, ONE-METHYL-	U-2
GUANINE, SEVEN-METHYL-	U-12
GUANINE, EIGHT-OH-SEVEN-METHYL	U-12
HIPPURIC ACID	U-12BHJ,AA,AC
HIPPURIC ACID, ORTHO-AMINO-	U-2
HIPPURIC ACID, ORTHO-HYDROXY-	U-2
HIPPURIC ACID, META-HYDROXY-	U-2
HIPPURIC ACID, PARA-HYDROXY-	U-2
HISTAMINE	S-T,AG F-Z U-12
HISTAMINE, N-ACETYL-	U-2
HISTAMINE, THREE-METHYL-	U-2
HISTAMINE, ONE,THREE-DIMETHYL-	U-2
HISTAMINE, ONE-METHYL-	U-2
HISTIDINE FREE	U-1BH
HISTIDINE COMBINED	U-2B
HISTIDINE TOTAL	S-3BLV,AG F-5BR U-12BHU,AB
HISTIDINE, ONE-METHYL-	U-2U
HISTIDINE, THREE-METHYL-	U-2
HISTIDINE, METHYL-, CONJUGATED	U-2
HOMOGENTISIC ACID	U-H
HYDROCORTISONE, TETRA	U-1
HYDROGEN	F-NW
HYDROGEN SULFIDE	F-NR
HYDROXYPROLINE FREE	U-BH
HYDROXYPROLINE COMBINED	U-B
HYDROXYPROLINE TOTAL	U-BH
HYDROXYTYRAMINE	U-5
HYPOXANTHINE	U-1
HYPOXANTHINE, ONE-METHYL-	U-1
IMIDAZOLE DERIVATIVES	F-5B U-1BH,AA,AC
IMIDAZOLE-FOUR-ACETIC ACID	U-2
IMIDAZOLE-ACETIC ACID	U-2
IMIDAZOLE ACETIC ACID, ONE-METHYL-	U-2
IMIDAZOLE-ACETIC ACID, THREE-METHYL	U-2
IMIDAZOLECARBOXAMIDE, FIVE-AMINO-FOUR-	U-2

INDICAN	U-125BHJ,AA,AC
INDIGOTIN	U-H
INDOLE	F-R
INDOLE-ACETAMIDE	U-2
INDOLE ACETIC ACID	U-E
INDOLE ACETIC ACID, METHYL ESTER	U-2
INDOLE-ACETIC ACID, THREE-HYDROXY-	U-2
INDOLE ACETIC ACID, FIVE-HYDROXY-	U-2
INDOLE-ACETYLGLUTAMIC ACID	U-2
INDOLE-ACETYLGLUTAMINE	U-2
INDOLE-ACRYLIC ACID	U-2
INDOLE-THREE-CARBOXYLIC ACID	U-2
INDOLE LACTIC ACID	U-2
INOSITOL	S-6DLV,AG U-125DH
IODINE	S-37FLV,AG U-12FH,AC
IRON	S-37LTV,AG F-5AF U-125FH,AC
KETOSTEROIDS	U-AC,
KYNURENIC ACID	U-2
KYNURENINE	U-2H
KYNURENINE, N-ACETYL-	U-2
KYNURENINE, THREE-HYDROXY-	U-2
LACTIC ACID	S-6EKLSTV,AE,AG U-12EH
LACTOSE	U-2
LEVULIC ACID, DELTA-AMINO	U-2
LEAD	F-5AFGXYZ U-125FX,AC
LEUCINE FREE	U-1BH
LEUCINE COMBINED	U-2B
LEUCINE TOTAL	S-6BL,AG F-5BR U-12BHU,AB
LEUCINE, ISO, FREE	S-6 U-1BH
LEUCINE, ISO, COMBINED	U-2B
LEUCINE, ISO, TOTAL	S-L,AG F-5BR U-12BHU,AB
LIPIDS	U-H
LYSINE FREE	U-1BH
LYSINE COMBINED	U-2B
LYSINE TOTAL	S-6BL,AG F-5BR U-12BHU,AB
LYSINE, HYDROXY	U-2
MAGNESIUM	S-67FLSTV,AG F-5AFGXZ U-12FHJX,AC
MALIC ACID	U-2
MALONIC ACID	U-2
MANDELIC ACID, THREE-METHOXY-FOUR-HYDROXY	U-2
MANDELIC ACID, PARA-HYDROXY-	U-2
MANGANESE	S-367FLTV,AG F-5AFY U-125FH,AC
MERCURY	S-AG, F-5F U-25F
METHANE	F-NRW
METHIONINE FREE	U-1BH
METHIONINE COMBINED	U-B
METHIONINE TOTAL	S-AG, F-2 U-12BHU,AB
METHYL ETHYL KETONE	U-2
METHYL MERCAPTAN	F-R
MYINOSITOL	U-H
NIACIN	U-1,AC
NICKEL	F-5AF U-125F,AC
NICOTINAMIDE	U-12
NICOTINAMIDE, N-METHYL	U-12D
NICOTINAMIDE, SIX-PYRIDONE	U-2
NICOTINE	S-V

NICOTINIC ACID	S-3DLTV,AG F-59D U-D,AD
NICOTINURIC ACID	U-2
NITRATES	U-S,AC
NITROGEN	S-TV F-ANWZ U-AC,
NITROGEN, AMIDE	U-2
NITROGEN, NON PROTEIN TOTAL	S-6B,AG U-B
NITROGEN TOTAL	S-67BL,AG F-5B U-12BH,AA,AC
ORNITHINE	U-12U
ORNITHINE FREE	U-B
OXALIC ACID	U-125HEJ,AC
PANTOTHENIC ACID	S-3DV,AG F-59D U-12D,AC
PHENOL	S-ETV F-5E U-12EJH,AA,AC,AD
PHENOL ETHEREAL SULFATES	S-KT
PHENOLS VOLATILE	U-2,AD
PHENYLACETIC ACID, ORTHO-HYDROXY-	U-2
PHENYLACETIC ACID, META-HYDROXY-	U-2
PHENYLACETIC ACID, PARA-HYDROXY-	U-2
PHENYLHYDRACRYLIC ACID, PARA-HYDROXY	U-2
PHENYLALANINE FREE	U-1BH
PHENYLALANINE COMBINED	U-12B
PHENYLALANINE TOTAL	S-6BL,AG U-12BHU,AB
PHENYLLACTIC ACID, PARA-HYDROXY-	U-2
PHENYLPROPIONIC ACID, META-HYDROXY-	U-2
PHENYLPROPIONIC ACID, PARA-HYDROXY	U-2
PHOSPHORUS	S-67FLV,AG F-56AFXZ U-2FHX,AC
PHOSPHORUS, INORGANIC	U-1
PHOSPHORUS, ORGANIC	U-1
PORPHOBILINOGEN	U-H
PORPHYRINS	U-EH,AC
POTASSIUM	S-37FLST,AG F-5AFGXZ U-12KFHJX,AC
PREGNANEDIOL	U-1
PROLINE FREE	U-1BH
PROLINE, COMBINED	U-2B
PROLINE	S-AG, U-12BH
PROLINE, HYDROXY-, CONJUGATED	U-2
PROLINE, HYDROXY-, TOTAL	U-12
PROPIONIC ACID	S-AE,
PROPIONIC ACID, PARA-OXYPHENYL	F-R
PURINE BASES	F-5B U-15BHJ,AA,AC
PURINE, SIX-SUCCINO-	U-1
PUTRESCINE	F-R
PYRIDOXAL	S-6DL U-1D
PYRIDOXAMINE	U-1KD
PYRIDOXIC ACID, FOUR-	U-12D
PYRIDOXINE	S-3DLTV,AG F-9D U-12D,AC
PYRIMIDINE	U-AD,
PYRUVIC ACID	S-AG, U-2HV
QUINALDIC ACID	U-2
QUINOLONE, FOUR-	U-2
QUINOLONE, N-METHYL-FOUR-	U-2
RESORCYLIC ACID, ALPHA	U-2
RIBOFLAVIN	S-3DLV,AG F-59D U-125D,AC
RIBOSE	U-2
RIBULOSE	U-2H
SALICYLIC ACID	U-2
SALICYLURIC ACID	U-2

SARCOSINE .	U-2
SCYLLITOL	U-H
SELENIUM	U-1F
SERINE FREE	U-1BH
SERINE COMBINED	U-2B
SERINE TOTAL	S-AG, U-12BHU
SILICON	U-15F
SILVER	S-AG, F-5FY U-5H,AD
SKATOLE	S-K F-R
SKATOL, ETHEREAL SULFATES OF	S-KT
SODIUM	S-37FLST,AE,AG F-5AFGXZ U-125FHJX,AC
SQUALENE	S-4CMS
STEARIN	U-AD,
STEROIDS, ADRENAL	S-AG,
STEROIDS, ALPHA-KETO-	U-1
STEROIDS, SEVENTEEN-HYDROXY-	U-1
STEROIDS, SEVENTEEN-KETO-	U-1
SUCCINIC ACID	U-2H
SUCROSE	S-KT U-2H
SULFATES, INORGANIC	U-2
SULFUR, INORGANIC	U-1FH,AC
SULFUR ORGANIC	U-H
SULFATES, ETHEREAL	S-K U-12CF,AD
SULFATES INDOXYL	U-AC,
SULFATES TOTAL	S-TV,AG U-2
SULFUR TOTAL	S-3FL,AG F-56AFXZ U-1FHJX,AC
SYRINGIC ACID	U-2
TARTARIC ACID	U-2
TAURINE	U-12BHU
TAURINE, CONJUGATED	U-2
TETRAHYDROCORTISOL	U-1
THEOPHYLLINE	U-1
THIAMINE	S-3DLV,AG F-59D U-125D,AC
THIAMINE, DI-PHOSPHO-	S-AG,
THIOCTIC ACID	U-2
THREONINE FREE	U-1BH
THREONINE COMBINED	U-2B
THREONINE TOTAL	S-6BL,AG F-5BR U-12BHU,AB
TIN	F-5FY U-12FH,AC
TOCOPHEROL	S-M
TRIGLYCERIDES	S-4CMS U-2
TRIGONELLINE	U-1D
TRIMETHYLAMINE OXIDE	U-2
TRYPTAMINE	U-2
TRYPTAMINE, FIVE-HYDROXY-	U-2
TRYPTOPHAN FREE	U-1BH
TRYPTOPHAN COMBINED	U-B
TRYPTOPHAN TOTAL	S-6BL,AG U-12BHU,AB
TRYPTOPHAN, N-ACETYL-	U-2
TRYPTOPHAN, N-METHYL-FIVE-HYDROXY	U-2
TYRAMINE, THREE-HYDROXY-	U-2
TYROSINE FREE	U-1BH
TYROSINE COMBINED	U-2B
TYROSINE TOTAL	S-6BL,AB U-12BHU,AB
URATES	U-H
UREA	S-37KLSTUV,AE,AG U-12BHJ,AA,AC

URIC ACID	S-37BKLSTU,AE,AG U-12BHJ,AA,AC
URIC ACID, ONE-METHYL-	U-2
URIC ACID, SEVEN-METHYL-	U-2
URIC ACID, ONE-THREE-DIMETHYL-	U-1
UROBILIN	U-1KE,AC
UROBILINOGEN	F-2KEGZ U-125EH,AC
UROCANIC ACID	U-2
UROERYTHRIN	U-2
UROPORPHYRINS	U-2H
VALINE FREE	U-1BH
VALINE COMBINED	U-2B
VALINE TOTAL	S-6BL,AG F-5BR U-12BHU,AB
VANILLIC ACID	U-2
XANTHINE	U-12
XANTHINE, HYPO-	U-2
XANTHINE, ONE-METHYL	U-2
XANTHINE, ONE-METHYLHYPO-	U-2
XANTHINE, SEVEN-METHYL-	U-2
XANTHINE, ONE,SEVEN-DIMETHYL-	U-2
XANTHURENIC ACID	U-2
XYLOSE	U-2
XYLULOSE	U-2H
ZINC	F-5AF U-12FH

Section 2. Other Diverse Excreted Substances

ACETOPHENONE O-SULFATE, TWO-AMINO-THREE-OH	U-2
ACIDS VOLATILE TOTAL	S-L F-5
ACTH	U-2
ALBUMIN	S-KT UAC
ALCOHOLS BRANCHED CHAIN	S-4M
ALCOHOLS STRAIGHT CHAIN	S-4M
AMYLASE	U-2H,AC
BACTERIA	U-H
BACTERIAL SUBSTANCES	F-G
BILE PIGMENTS	F-A
CADAVERINASE	U-2
CARBONIC ANHYDRASE	U-2
CATALASE	U-2
CITROVORUM FACTOR	U-12
ENZYMES	F-Z U-H
FERULOYL-GLYCINE-	U-2
FIBRINOLYSIN	U-2
GLUCURONIDASE	U-2
GLYCOPROTEINS	U-H
GONADOTROPHINS	U-2
HEMOGLOBIN	U-H
HISTAMINASE	U-2
HYDROCARBONS AROMATIC	U-AD,
INSULIN	U-2
LIPASE	U-2
LIPOPROTEINS	U-2
MALTASE	U-2
MELANOCYTE STIMULATING HORMONE	U-2
MENOTOXIN	S-AG,
METHEMOGLOBIN	U-H
MUCOPROTEINS	U-H
MYOHEMOGLOBIN	U-H
NORADRENALIN	U-2B
PARAFFINS	S-CS
PARATHYROID	U-2
PHOSPHATASE, ACID	U-2
PLASMALOGENS	U-2
PROTEIN	F-AZ U-1BH,AC
RIBONUCLEASE	U-2
SOAPS	F-CS
UROCHROME	U-2
UROKINASE	U-2
UROPEPSIN	U-H
UROPEPSINOGEN	U-2
WAXES	S-4CS

Section 3. References for Combined Products Tables

Code Symbol From Table	Excretion Product	Page Number In Reference	Reference In Biblio
1	U	363	(Altman-61)
2	U	919	(Long-61)
3,4	S	467	(Altman-61)
5,6	U,F,S.	5	(Wallman-60)
7	S	469	(Altman-61)
8	S	56	(Spector-56)
9,A	F	3,26	(Goldblith-61)
B,C,D,E,F	U,F,S	209-213	(Albritton-53)
G,H	U,F	526-534	(Diem-62)
J,K	U,S	4-5	(Ingram-58C)
L,M,N,P,Q	F,S	8-19	(Mattoni-62)
R	F	21	(Ingram-62)
S	S	53	(Breeze-61)
T	S	1	(Ingram-57)
U	U	579	(Thompson-57)
V	S	210	(Robinson-54A)
X,Y,Z,AA,AB, AC,AD,AE	U,F	258-260,352-368,488	(Sunderman-49)
AF	F	333	(James-61)
AG	S	223	(Kuno-56)

Notes on the Use of the Chemical Substance Tables

Data were sought which would include "normal values"(eg. Spector-Handbook of Biological Data-1956; Sunderman-Normal Values in Clinical Medicine-49). These are supposed to take into account these factors:measurements are made within the North Atlantic(American and European)community, on healthy adults, on normal mixed diets, with environment, rest, workload, intake, and adaptation conditions standardized to common conditions at the time of measurement, and so described.

In general, each reference(eg. Spector-56) provides such information as:mean value and dimensional units, statistical dispersion of values, analytic technique, conditions of experiment, and further reference to original method source paper. For some references, the author has simply assembled values from a number of good sources cited.. The reader may gain added confidence in a mean value of amount of a given substance produced, by combining values from several sources cited in the table.

Caution must be exercised, in extrapolating from the values obtainable from these sources, under temperate conditions, to those circumstances involving high temperature, workload, water or food pattern alterations, or other stresses, which can greatly change the amounts of released substances. Additional help on this may be obtained from references cited in this report on changes in body products under heat stress conditions.

For supplementary data on other urine, feces, skin products not in table, see discussion pages on these substances which follow.

Utilization of the data in various studies suggested in this report would be aided by arranging the substances in the table into categories based on major chemical structural groups and arrangements.. This can help in study of separation processes(eg based on solubility, mobility, diffusion, reaction specificity, etc), on analysis of spectral properties, on matchup with specific biosensor chemosensitivities, etc. Another useful grouping would rank the substances in order of absolute amount from all channels, released into environment, on a daily basis(eg. total chlorides from feces, urine, skin/day). The top group might be selected for preliminary analyses of system sensitivities, etc. The same grouping can be used to aid in selection of substances which would show high contrast ratios with other materials in environment, or are uniquely identifiable as produced by humans or higher animal organisms. These could include, for example, low molecular weight hormones liberated in trace quantities such as steroids, adrenalin and catecholamines;it should also consider substances poorly defined chemically(and not on the table), of high molecular weight, including proteins & polypeptides, lipopolysaccarides, which even in minute traces can be identified as unique to the individual and species by serological methods.

b. Additional Data on Specific Body Products.

1. Skin Products

(a). Sweat .

Supplementary data on sweat composition includes the following: Iron(Consolazio-63B), (Mitchell-49), vs diet(Johnston-50); Calcium(Consolazio-52)(Johnston-50)(Mitchell-62A);Sodium(Bulmer-54), (Consolazio-63-B);Potassium (Bulmer-54)(Consolazio-63B);Chloride (Ladell-48). For Nitrogen compounds(Mitchell-62A)(Consolazio-63A, 63C), vs. diet protein and salt(Cuthbertson-34). On other composition factors: for salt composition(Werner-52)(Gibbs-62A); composition and colligative properties(Foster-61); solute excretion rate, physiological factors(Barrueto-59), (Bass-59).

Source data on sweat composition and volume also exists in papers on thermoregulation. See: evaporation studies(McCutcheon-55), (Taylor-53A, 53B);rate and discharge patterm(Albert-51)(Peiss-51);for responses to high temperatures, see(Lloyd-61), salt and water endocrine control(Collins-63); high temperature responses as function of humidity(Lyburn-56), and of acclimation(Dill-38)(Von Heyningen-49). For studies of desert responses, see (Adolph-47), for other temperature effects(Lloyd-61).

For other related references on sweating:for measurement, see (Robinson-54B), drugs altering sweat mechanisms(Randall-55), skin evaporation with inactivated sweat glands(Pinson-42), sweat glands as extra-renal regulators of chemical substances(Schwartz-60), comparative physiology(Schuman-62), sweating in illness(Lobitz-61), lack of ethnic differences claimed in basic sweating pattern(Hansen-61), and recent general reference(Schuman-62).

(b). Sebum.

Supplementary data on this special glandular secretion includes the following:Sterols: cholesterol(Boughton-57), others(Brooks-56)(Spector-56), (Ramanathan-58)(Boughton-59)(Horacek-59). For fatty acids:straight chain saturated and unsaturated, with under 20 carbon atoms, see(Boughton-59),(Javes-56) (Spector-56); including caproic and caprylic(Eller-41);capric(Decanoic)(Jones-56). No branched chain or hydroxy fatty acids are seen in Spector's listing. Some fatty acids on skin are believed to be derived from sebaceous gland lipids, split on skin by lipase in normal bacterial flora(Strauss-59). Other Lipids: triglycerides(Horacek-59), di and tri glycerides, waxes(Haahti-61A), phospholipids(Wheatley-53), choline lipids and plasmalogens(Horacek-59), other unsaponifiable fractions(Boughton-59A, 59B). Alcohols: straight and branched chain(Spector-56), others (Boughton-59). Squalene :(Mackenna-50)(Wheatley-53)(Spector-56)(Ramanathan-58), (Haahti-61A). Other hydrocarbons:(Spector-56).

For other sources of information on composition, for that from individual glands, see (Suskind-51), for composition independent of dietary factors (Ramanathan-58) but altered in disease(Schmidt-Nielson-51)(Wheatley-56), and for survey(Mackenna-52).

For homeostatic control of sebum production, and its alteration by endocrines, see (Hershey-59)(Horacek-59);for relation to sex hormone activity (Strauss-56), alteration in output in females by drug Enovid(Strauss-63), and in males vs. male and female sex hormone administration and castration. These latter responses give rise to the interesting speculation that sebum and its gland are remnants of a scent communications organ(Schaffer-37)(Wheatley-56), of the type described for various animals and discussed in this report, and that the gland product as released (or unmasked by bacterial action on skin) matches active and existing chemoreception processesin man, with perhaps a subconscious perception of the event, and consequent action in human relationships. (Note that the perfumer's blends include animal scent substances; Norbert Wiener calls perfumes'exterior hormones'). Human sebum products are believed by various tracking dog handlers to be the principal class of sub-stances produced by man and smelled by the dog in tracking. (See Biosensing, Dogs). One class of important experimentswith sebum which must be carried out is to prepare quantities of whole sebum, or its fractions(chromatographed, etc) for use in controlled dog tracking experiments.

For other information on the sebaceous gland; for its biology, see (Rothman-54)(Kuno-56)(Kilgman-58)(Shelmire-59). For analytic methods, for early quantitative determination(Emanuel-36, 38), for collection techniques, see(Van Heyningen-52)(Strauss-51);for modern gas chromatographic microanalysis of many sebum products, see(Haahti-62), who also uses Infrared detection with one chromatograph(Haahti-61A).

(c). Skin Product Alteration by Bacterial Action..

The normal skin bacterial flora, described by(Levans-50), is one agent responsible for the transformation of known groups of substances released from the several glands, into a time-dependent uncertain mix of chemical substances, requiring further identification by chromatography, etc. Bacterial lipases are claimed to split fats into fatty acids, and contribute to odor(Strauss-59). See also (Strauss-56). Other non-bacterial enzyme degradation, autolysis, probably contributes other fragments to this brei.

(d). Skin Products Attracting and Repelling Animals..

For many mosquito studies on skin products, see(Brown-51, 56), (Rahm-57A, 57B), for mechanisms of attraction: see(Rahm-58A, 58B), for individual human differences sensed(Brouwer-59, 60), for identification of the specific palpa and tarsal chemoreceptors involved(Rahm-58A), for skin amino acids as major attractants(Brown-61A), including lysine(Brown-61B). For other mechanisms of attraction of mosquitoes to humans, see(Mer-47), (A Parker-48), (Willis-47, 48), (Thompson-55).

For a study of human skin products, particularly serine, repelling fish (salmon), see (Idler-55).

(e). Human Odor from Skin.

For body odor in man, its reception, significance, control, see (Neuhaus-61), for human individuality in odor(Laird-35)(Lohner-24). For individual and ethnic difference studies, see(Eller-41)(Adachi-03)(Laloy-04A, 04B).

(f). Other Sources of Data on Skin Properties and Products).

For reviews on skin, see(Markowitz-42)(Rothman-54)(Kuno-56)(Shelley-58). For eccrine gland studies, see(Lobitz-61)and apocrine glands(Shelley-60);for factors affecting secretion process(Kerslake-54)(Kawahata-53), for neural regulation and emotional stimuli(Kennard-63);and for other skin physiological data (Lemaire-56). For apocrine secretion correlates with sex hormones, see(Straus-56), and for induction of asthma by skin products, see(Jamieson-47).

2. Urine Products

For supplementary data on urine components: for basic amines, see (Scriber-59); amino acids (Stein-53)(Evered-54, 56)(Soupart-59) and their seasonal changes (Hale-59), polypeptides (eg. aspartyl, glutamyl)(Buchanan-63). For protein trace concentrations quantitatively determined in normals, see (Tidstrom-63). For 17-OH-corticosteroids (including pregnandiol), see (Garlock-63).

For other papers of utility in this study: for Ca and Mg vs. galactose input, see (Heggeness-60); for aldosterone vs. heat acclimation (Fletcher-61), electrolytes vs. cold diuresis (Bass-54); for other dietary influences (Sargent-56). For a good sequence of papers identifying urine components in closed cabin wastes, see (Ingram-57, 58A, 58B, 58C, 61, 62).

3. Fecal Products.

For additional data on composition; for sterols, see (Aylward-62); for other common lipids (Watson-37)(Gordon-57), also measured in S. African whites and Bantus (Antonis-62). For bile acids vs. diet fat (Gordon-57)(Haust-58). For Ca & P in Africans (Holemans-62). For several references identifying fecal solids and liquids in closed recycling systems, see (Ingram-58A, 58B, 58C, 62).

For g.i. gases, composition and quantity, see (Kirk-49)(USAF Handbook of Bioastronautics). For colonic amounts, see (Fries-06), alteration with diet in rats (Hedin-62)(Whitehair-62); forformation vs. diet in humans, Japanese (Kodama-49); for volume in the whole g.i. tract (Blair-43, 47B) and in colon (Fries-06), for alterations with altitude (Steggerda-47, 55).

4. Respiratory Products.

For normal persons breathing atmospheric air of standard composition, the only products archived in the literature are the usual O_2, N_2, H_2O, CO_2, for expired air, even in the literature of closed system studies; and no information on other substances enters the combined chemical substances tables. Information available turns out not to be directly applicable, on expired products under other circumstances; in disease states (eg. acetone in diabetics)(Steward-61); g.i. and respiratory products expired deriving from unusual foods (eg. garlic)(Haggard), and substances expired after the detoxification and excretion of drugs and poisons(as described in the several handbooks of toxicology.

c. Other Supporting Information on Body Products

1. Ethnic and Regional Differences in Human Products

Some data providing ethnic comparisons and geographic regional measurements (other than North Atlantic values), on urine, feces, skin products and certain physical properties, are set down on the following pages. Such data were found to be sparsely scattered through the literature, and should be considered illustrative but not complete. They were obtained in an intensive search for "normal values" tables and lists from other regions, using a variety of Boston and East Coast reference collections. To go further, the reader might seek regionally published medical teaching texts on biochemistry and physiology, clinical pathology, civil hospital center and military medical service manuals on clinical lab technique, normal values, experience data.

Except for data obtained by authors carrying out comparative ethnic studies, it is hard to determine whether values are related basically to ethnic considerations, and if experiments balanced out factors of climate, workload, health vs disease, body size and weight, diet, various adaptations, and considered other experimental standard conditions. Only if the true controlled-experiment ethnic base data can be extracted from these papers and others by the same productive authors, a table of values could be built for each group for comparison with "North Atlantic normals" in attempt to unearth significant differences in individual components concentration, or mixture concentration profiles.

Urine Components: Ethnic comparisons were made, for amino acids: in Europeans, Malaysians, Chinese (who showed high taurine (McEvoye-Bowe-61), in Chinese vs. caucasoids with diet ruled out (Chinese show higher alanine, lysine, tyrosine, histidine, B-amino isobutyric acid) (Sutton-55). Comparisons were made, for 17-Ketosteroids and creatinine in Indians, Chinese, Malaysians, Negrito, Senoi (Lugg-57), for 17-Ketosteroids in North and South Indians, Europeans and African negroes (Barnicott-62). To compare nitrogen products and vitamins for several groups, Interdepartmental Committee on National Nutrition for National Defense Surveys of : Thailand, Ethiopia, Lebanon, etc. For various minerals, (traces of (Mn, Cu, Pb, Al, etc) in French, Americans, various Mexican groups including Indians see (Kehoe-40) who relates these values to the mineral distribution in the soil where these individuals spent their early life. This can be an important "tracing tag".

For specific regional measurements: for India, for nitrogen fractions, for urea, creatinine, ammonia, as function of diet, see (Ramamurti-55) for amino acid, urea and ammonia values (Phansaekar-54) for other nitrogen (Gokhale-63). For 17-Ketosteroids, in normal and under-nourished (Ramachandran-56); North vs. South Indians (Barnicott- 52); for relation to estrogens, pregnandiol (Patwardhan-57) and (Friedman-51), (Bharadwaj-57) and other studies related to serum Na and K (DasGupta-56). For adrenalin and other catecholamines, see (Subrahmanyan-60)(Sheth-62). For creatinine see (Lugg-57), sulfur (Pathak-61); chlorides (Ramanathan-60)..

For Japanese, for amino acids see (Muratar-59) and related genetic studies (Iwata-59); 17-Ketosteroids (Jap. Nat. Inst. Nut.-60); Ca (Ishizawa-62); Na and K (Fujioka-60); various bases (Yamamoto-59); and general urinalysis (Saito-60) (Fujii-56).

For Chinese, for amino acids (lycine, alanine, taurine, glutamine, cystine, B-amino isobutyric acid) see (McEvoye-Bowe-62) and (Sutton-55) whose measurements are cited under ethnic comparisons. For alpha-keto acids (puruvic, alpha-keto glutaric acid (Liu-62); creatine (Bowress-58); 17-Ketosteroids (Bowress-58) (Lugg-57), thiamine (Liu-62); Coproporphyrin (Dept. of Indust. Health, Szechuan, China-60).

For Malaysians, for amino acids(McEvoye-Bove-61), 17-Ketosteroids (Lugg-54, 57).

For Africans 17-Ketosteroids (Barnicott-52) and in West Africans, 5-hydroxy-indole-acetic acid (Foy-62).

Fecal Components: For ethnic comparisons, for minerals in French, Americans, various Mexican groups, see (Kehoe-40) discussed under Urine.

For specific regional measurements: for Africans; K and P (Holemans-62); South Africans, bile acids (Lewis-57), lipids vs. diet in whites vs. Bantus (Antonis-62); Japanese: intestinal gases, related to diet (Kodama-49); for Ethiopia, Lebanon, Thailand proteins, other nitrogen, vitamins (see (Interdept'l ctee. Nut. Nat. Def.) papers cited earlier.

Skin Products: For regional measurements: India; sebum composition (Ramanathan-58), iron (Hussain-59, 60; NaCl with heat and exercise (Ramanathan-56). For Africans; nitrogens, as ammonia, urea (Darke-60).

For ethnic comparisons, of sweat gland distribution differences in Eskimos: Negroes, Caucasians see (Kawahata-61) and see material under biosensing, human smell for papers discussing ethnic odor differences.

Physical Properties

Skin spectral reflectance ethnic comparisons were made, for white vs. negro in the visible region (Buttner)(Kuppenheim-52), (Pfleiderer-62), in the infra red (Wright-34)(J Hardy-56)(Buttner)(Kuppenheim-52) (Pfleiderer-62) and in the ultraviolet (Jacquez-55A) (Pfleiderer-62). For similar measurements, in Japanese: for visible and IR, see (Jacquez-55D), for UV see (Jacquez-55A); For Mexicans, see (Lasker-54). For other spectro-photometry for skin color see (Weiner-52) skin color used to study inheritance (Harrison-56); for spectral reflectance differences with age, sex, race, see (Edward-39).

Other Ethnic Comparisons in Biological Data:

For heat acclimation comparisons vs. anthropological difference (Newman-55), Europeans vs. Asians (Adam-53) white vs. American negro (Baker-58A) and white settlers in tropics (Price-39), for others, see (Baker58B) (Strydon-63). For various diseases, ethnic, sex, race, vs. host factors (Damon-62), disease ecology (May-58, 61A), psychiatric ecology (Meerloo-59). For Far East malnutrition ecology (May-61B).

2. Regional Diet and Nutrition Data Sources.

Data set down in the combined substance table and supplementary lists derives chiefly from people under normalized conditions, including mixed diets of North Atlantic countries(European and American). In looking for excretory products data and diet data from other world regions, extensive review of the past and present world literature in many document collections, and in at least fifty periodical titles in nutrition, metabolism, dietetics, etc. has not revealed much information presenting human excretory products in orderly array, directly related to diet or diet modifications, except in malnutrition states.

To explore further available information on dietary influences on body product, the reference sources set down in this section may prove of value, beyond their first review for this report. To go further with the problem, the reader must seek data going beyond generalized nitrogen balance studies which represent most of what is set down about body products in these papers. Ethnic and Regional Difference data referred to in the adjoining section probably are contaminated with a major factor relating to diet composition, which a discerning reader may be able to separate out for significant diet and body product correlations. Additional references from the same productive authors listed should be consulted, and the pursuit of indigenous texts, manuals and other publications, in the manner described in the Ethnic section, is recommended.

For Far East data on diet and nutrition: for Indonesia, see (Postmus-55); Thailand (US-ICNND-61); Malaya (Leong-52); India (Wittfogel-57); (Hussain-51); China(Wittfogel-57)(Worth-63); Formosa(Jolliffe-56) & Chinese Nationalist Army (Pollock-56); Pollack's is an especially good series of several papers in a symposium on Far East nutrition, with metabolic, anthropological, and clinical approaches, including limited balance and excretion studies.

For other regional data, for studies of the Interdepartmental Committee on Nutrition for National Defense, consult Dr. Arnold Schaeffer at National Institute for Arthritis & Metabolic Diseases. For tropical nutrition, see(Nicholls), (NY Acad of Med. -60). For regional protein malnutrition studies, see long series of papers by Dr. Nevin Scrimshaw, of MIT Dept. of Nutrition. For other malnutrition data, on starvation, see(Keys-50)(Gilman-50); and for Far East malnutrition(May-61).

For other general references on nutrition and its correlates: see the food encyclopedia(Ward-41), biblio(Baker-58), general text(Joliffe-62), and comparison of world's food(Bennett-54); for food habit research, see(Bottlieb-61), & habit origins(Renner-44), unusual foods(Black-53), meat taboos(Simmons-61), other strange food customs(Harris-62), balance in strict vegetarian diet(Guggenheim-62); for environment effects on food habits and intake, see(Peryam-60), for nutrition and climatic stress(Spector-54A)(Buskirk-57) and high temperature nutrition(Salganik-59).

For food chemistry, see (Jacobs-51); chemical composition tables (Chatfield), and comparative data(Harris-48); for trace elements in foods(Underwood-56). For nutritional biochemistry and status studies, see(Lowry-52), (Bourne-53), (McCance). For protein needs and excretory products, see(UN-WHO), (Spector-54-B0(Allison-60). For survival ration needs, see(Roth-43)(Davies-55).

3. Closed Cabin Ecology Studies..

Data have been sought for additional definition of human body products, from those studies of closed environment systems where such information is of great significance in the design of life support controls and recycling and recovery systems for certain substances. For general studies: for extraterrestrial bases, see(Holbrook-58)(Bates-61), on aerospace cabins(Konecci-59), (Clamann-58), on Soviet space systems(Gazenko).

For environment (gas and vapor)composition, including human products: for space cabin contaminants measured by gas chromatography revealing much organic detail, see(McKee-63). For submarine environment, contaminant measurement, data and techniques, see the many papers of (Nestler-58, 59), (Piatt-60A, 60-B)(Ramskill-60); others on organic contaminant identification (Johnson-56, 62), (Thomas-60)(Umstead-60), and (Miller-60). Of special value is the chemical analysis and description of non-human sources of contamination in submarine environments(foods, tobacco smoke, lubricants, plastics, etc) by(Arnest-61).

For design information relating to closed environment human products and atmosphere composition, see(Chasen)(Palevsky-57)(Bursak-60)(McCandles-60), (London-62)(Dryden-56)(US-ASTIA-Bib-62). For waste disposal, for recycling of identifiable components, for feces(Goldblith), comprehensive studies of (Ingram-56, 58A, 58B, 62), also(Golueke-59)(DesJardins-60). For closed system water purification and other recovery, see(Fair-54)(Konikoff-60, 61)(Bennett-58), (Ingram-58C)(Zeff-59)(Olson-61)(Rich-61)(Mancinelli-63), extensive review (Pipes-NRC);, and other papers on urine recycling(McNeil-54)(Moir-59)(Sendroy-59)(Hawkins-58)(Ingram-61).

For contributions which these measurements procedures used by some here can make to the human products sensing problem, see(Chemical Products Sensing, Physical Methods),, in this report.

4. Human Chemical Composition.

Information on this attribute of human tissue can aid in study of remote sensing systems involving physical links related to atomic and molecular composition, described elsewhere herein(eg. x-ray fluorescence, radioactivation analysis, reflectance spectroscopy in all regions).

For general chemical composition, see Handbook of Biological Data (Spector-56), & (Piron-Reatequi-61).

It would be desirable to look beyond the studies of (Kehoe-40) who investigated variations in human excretory products (trace minerals)related to soil composition of environment where subjects had grown up;into review of body composition for the same minerals correlated with environment of origin.

II. Physical Attributes.

a. Electromagnetic Radiation Contrasts

1. Infrared

For skin spectral reflectance measured to 1 micron (U), see (Jacquez-54, 55B) (Kuppenheim-52) who shows White max. 0.7-0.8U, Negro max. 0.9U. Further out to 2.5U, (Jacquez-55D) claims 55% total reflectance to 1U, 5% beyond to 2.5U, with all Negro-Japanese-White differences under 1.2U, and (Hardy-56) describes angular variations, in isolated skin. For data to 10. U and 3.5U Negro peak versus White skin, see (Buttner) and for earlier data to 14. U for Negroes and Whites see (Hardy-34A). For other diffuse data see (Clark-53).

For transmission and absorption data (from which reflectance may be inferred), to 2U, see (Hardy-34); to 2.5U (Pfleiderer-62); for skin reaction from IR (Hardy-54) including heating (Hendler-57).

For skin spectral emission, 1-14U, showing emissivity over 0.99 for White and Negro skin above visible, see (Hardy-34A) (Wright and Telkes-34), and 1-15U in isolated skin, White and Negro (Hardy-56). For "IR" radiometry of whole body for clothing design, see (Veghte-61) discussed as "thermography" (Barnes-63).

For nervous system emission speculation, see (U.S.A.F. Procurement Office, Aerospace Med. Lab., Dayton) invitation for study on possible emission of "non-thermal" IR from CNS.

2. Visible

For skin spectral reflectance, see (Buettner-37) (Goldzieher-51) (Derkson-52), (Kuppenheim-52), (J. Weiner-52B) (Jacquez-54, 55A, B), (Hardy-56) (Harrison-56), good work of (Buckley-61), A.F. Special Weapons studies (Derkson-54); for diffuse reflectance (Krolak-55) and changes after sunlight exposure (Edwards-39).

For skin spectral transmission data, see (Hansen-48), annual report lists of Naval Materials Lab, Brooklyn Navy Yard on Simulated Weapon Thermal Pulse Studies.

For clothing and personal equipment data, see (Krolak), also QM Laboratories clothing and textiles reports in their annual lists of publications.

3. Ultraviolet

For skin reflectance from 200 MU to edge of visible, 8% total reflectance stated by (Goldzieher-51), describing in detail bands seen due to amino acids (e.g. tyrosine) at 290 MU, also proteins, nucleic acids, hemoglobin, melanin, and carotene, UV excitation adds 20% to reflectance in non UV regions (Jacquez-54) who from 200 MU up finds no Japanese, White or Negro reflectance differences, but hemoglobin bands common to all at 420 and 600 MU, (Jacquez-55A). For other reflectance spectrophotometry of different skin layers after UV erythema, see (Jansen-53).

For skin transmission data 220-360 MU, see (Runge-62) and UV transmission through various skin layers (Bachem-29) (Hansen-48A, B), and UV skin spectrometry (E. Edwards-51).

For interesting property, after 250 MU excitation of skin (isolated), free radical production, measured by Electron Spin Resonance (ESR) (Norins-62) techniques. This contrast factor could give rise to possible new class of non-contact detection methods (see Physical Methods for Chemical Analysis, in this report).

4. Microwave and RF

For skin reflectance (data quite hard to isolate from the wealth of diathermy absorption and action data), 70% reflectance, at 1.27, 3 and 10 cm. (like water) claimed (England-49, 50). From 3-300 cm. reflectance 60%-100% stated (Maskalenno-58). For other 3-300 cm. measurements (Nieset-61). 50%, from 3-75 cm. inferred from absorption cross section data (Anne-61).

For body absorption data (for inference of other reflection properties) see (Rajewsky-38), (Saito-60), (Anne-62). For mechanisms (Schwan-56A, B) including coupling and interactions in diathermy Schwan has published much on dielectric constant and conductivity by differences in various isolated tissues (Schwan-54), and 3-75 cm. measurements in human "phantom" replicas (Anne-61).

For clothed person reflectance in cm. and mm. regions (radar cross-sections) and properties of anti radar detection clothing, see (U.S. Army QMR and E Procurement Office) for recent invitations for proposals to study these, and for background reports which preceded these IFP's.

For body emission, the normal heat emission from man with maximum radiation in the near infrared, has a continuous "tail" into the microwave region, disce. ible from background with a sensitive microwave radiometer (see Physical Sensing).

For speculative information of RF excitation of man producing "heterodyned" radio signal emitted from brain see (Cazzamalli-25). A book reprinting several years of his work, published in Italian in 1960 is reported to exist by ERDL personnel (M. Gale, Mine Detection Branch).

Note that microwave and tissue interactions are involved when ESR (electron spin resonance) techniques are used to view free radicals produced in skin by UV excitation (see UV above).

Also speculative is the suggestion that CNS produces very low frequency (under 1KC) low intensity radiated signals. No observations were seen published on checking this hypothesis with currently available nanovolt sensitivity very low frequency receiving equipment and amplifiers, such as are used for atmospheric whistlers, geophysical seismic electric and magnetic field data, solid state phenomena, etc.

5. X-ray Contrast

No specific data on reflection or back-scattering can be reported here, but a potential contrast factor lies in the human body elemental composition, abundances of certain elements (e.g. calcium and phosphorus) in certain special configurations (skeleton) perhaps atomically distinguishable by x-rays from other organic and mineral background.

Encouragement derives from ERDL study reports (Porges-58) (Gravitt-62) on x-rays for mine detection (e.g. for mercury, etc. in the explosive accessories). Signal return possibilities from tissue include x-ray fluorescence techniques (x-ray return signals in back-scatter at longer wavelengths than exciting beam of 220 KV energy, and characteristic of certain elements, requiring very stable high intensity X-ray source, energy-sensitive detector, etc);and elastic(Rayleigh)back scattering, again using sources over 100 Kv. It may be worthwhile in a short study to examine intrinsic factors of X-ray contrast in humans; parameters which govern their excitation and their detectability in background; and the available possibilities for obtaining the required new sources(of high intensity, narrow beam, pulsed, narrow band, highly stable-perhaps all in a fashion describing a hypothetical coherent x-ray laser source);also suitable detectors.

b Sound and Vibration Contrasts

For human body surface sound reflection data, given as 1-2% for 1-20 Kc/s, see (Ackerman-62). Further inferences on reflection may be made from papers on: mechanical impedance of body surface(Franke-48, 49, 51A, 51B), (Von Gierke-50, 52, 59), (Ostreicher-50), (Ludwig-50), and other reports listed in those report summaries from(USAF Bioacoustics Lab-WADD-60), and CHABA (Committee on Hearing and Bioacoustics)report list(Whitcomb-63). For other data on ultrasonic interactions, see(Lehman-53), (Kelly-57), (Heuter-58).

On sound emission: human movement creates sound;not only walking, etc., but activity "at rest"(to change weight and contact pressure distribution, circulation return -a series of obligatory movements, without which discomfort and actual lesion develop, as in bedridden paralytic decubitis ulcers). While measurements of such noises would seem to be easy, no good systematic data on this could be found, even in search on exaggerated movement, among disturbed persons, as might be recorded in the psychiatry journals. Possible sources include Human Engineering data(e. g. Franklin Institute and Case Institute of Technology various studies on body-seat contact pressures and measurements), information from rehabilitation and physical therapy sources.

Normal respiration contributes a very minor sound background, except after very intense exercise. There was sought without success data on normal respiratory external airborne sound measurements;none appear in major respiratory normal or pathological physiology sources. Perhaps sound spectrogram data are to be found in back files of acoustical journals (eg. JASA) and speech communication periodicals(eg Bell Lab Tech Jnl.).

Ejection of blood from the heart produces a body recoil pattern externally measured clinically as the BCG(ballistocardiograph). See (von Wittern-53), many papers of Isaac Starr. This signal level is much to low to excite micro seisms which would be detectable even in the ground immediately around the man.

No characteristic data have been found on noises of daily tasks, food preparation, weapons handling, except the few on shipboard crewspace noise listed under Environmental Modifications. For other data on sound and vibration contrasts, see section on Interaction of Sound with Humans, under "Behavioral Responses".

c. Electrical Properties.

Internal sources of systematic biopotential pattern observed include the heart, various muscles, brain, etc. with signals manifest in skin surface measurement of repetitive signals in some cases, at millivolt levels(electrocardiogram), microvolt levels(muscle electromyogram, eye electroretinogram, eeg). No non-contact or remote observation techniques for these phenomena have been found explicitly reported in the literature to date.

No other human electric field emssion or pattern is reported, although it is claimed(Burr-49) that electric fields are produced around nerve tissue (isolated nerve, 150 microvolts measured at 1 cm), and that persistent electrical field configurations found around organisms and within them, are associated with growth patterns, etc(Burr-34).

No published data were found on human disturbance of natural earth electrical fields(described under Environmental Modifications. .), or remotely measurable interactions with strong fields applied to surroundings. Such information might reasonably be obtained experimentally by placing humans in the environments of sensitive terrestrial electric field observatory instruments, as maintained as several Federal Geophysical research stations.

For other data on human and animal electrical interactions, see Electrosensing(under Biosensing) and Electric Signals Inducing Sensation(under Induction of Behavioral Responses).

d. Magnetic Properties.

Search of the literature reveals no data reported on human production of magnetic fields, although (Morrow-60) describes measurements of magnetic fields around neurons, in isolated nerve. Contact should be made with the Proceedings of the Annual Biomagnetics Conferences(Barnothy-62), the continuing reviews on biomagnetism(Alexander-61), (Jacobius at Library of Congress).

No data are available on human disturbances of the natural geomagnetic field or its rapid minor fluctuations, or detectable interactions with strong applied magnetic fields, as measured remotely. Simple field experiments, on such possibilities and on the detection of the human inhomogeneity in the surround, might be carried out, for example, in the vicinity of the subgamma-sensitivity magnetometer array at Boston College, where observatory for geomagnetic fluctuations is maintained for Air Force; one should look into experiments possible with aid of Naval personnel involved in sea surveillance magnetometer instrument development(Naval Research Lab; Naval Air Devel. Center, Johnsville)

For other data on living organism behavioral responses to magnetic fields (without identification of discrete sensors), see Magnetic Field Sensing, under Biosensing; for magnetic fields inducing human sensation, see Induction of Behavioral Responses in this report.

e. Radioactivity.

Natural radioactive isotopes in human tissue emit signal(K^{40}, also C^{14}, Cs^{137}, Ca^{45}), described by many(Hirsch-55)and measured on large groups for control data on fallout(Onstead-60). Though the low signal is normally measured in the laboratory in low level systems compensated for background, and with long time integration, improvement in detection theory and instruments may bring observation of human self-emission into the realm of possibility for close ranges, for elements of higher abundance in tissue than in environment, and those with certain emission peculiarities.

Radioactivation of specific chemical elements in body to yield radiation and particle emissions with characteristic energy and decay patterns, has its counterpart in chemical analysis techniques(described under Physical Methods of Chemical Analysis). This has been a sensitive technique for body products brought to the measuring apparatus(Tobias-49).

Phosphorus, Potassium, Sodium are thus observed(Reiffel-57);Strontium, Barium, and many trace elements(Harrison-55). Also see radioactivation analysis biblio(Gibbons-57).;nuclear radiation interactions with optical, thermal, electrical and other physical properties of solids(Gex-61), and neutron radiography techniques(Schultz-61).

One may speculatively consider exploitation of these concepts, by remote illumination of subject, with bright collimated beam of suitable high energy radiation or particles, penetrating air for useful ranges, for which relatively large absorption cross sections exist in elements characteristically abundant in man(relative to environment), with back-scattering and re-emission of usable levels of some different characteristic emission, efficiently sensed by detector with appropriate background discrimination properties and response time. Encouragement in part(for the detection aspect can dervie from analyses made over several years, of practical radioactive all-weather glide-path landing aids for aircraft(Haefner-62). These provide, for ground-to-plane path lengths to several hundred feet, sharply defined spatial patterns and beams, allowing adequat e glide angle resolution, with measurement response times short enough for useful attitude and glide path control, without aircrew hazard from received radiation. In their case, they used Co^{60} pellet sources, in small lead boxes with collimation apertures, planted on ground. In the case here, human stimulated emission return will be extremely low level, unless the analysis considers delivery of very large radiation of particle fluxes to the target(and these may in themselves be incapacitating).

f. Body Profile and Geometry

A variety of active and passive observational techniques require knowledge of body configuration and its projected area presented at various positions of rest and work. For these Human Engineering data, consult(Hertzberg-56), (Hansen-58). For effective human radiating area (applied to IR studies) see (Bohnenkamp-36), (Gruber-51). Similar data are obtainable on effective physical cross-sections, from sources cited herein on "Electromagnetic Radiation Contrasts".

D. ENVIRONMENTAL MODIFICATION OF SIGNALS FROM MAN

Analysis of remote detection of some human signal or property must consider distortion of this signal in environment due to background "noise", and transmission loss factors. To get at this problem source data are available and cited below, on bioenvironment (animal and plant) systematic description; chemical environment background (from animals and plants) and chemical transmission factors; physical environment: background and transmission, for electromagnetic, acoustic and seismic, and electric and magnetic field properties of earth. Radioactivity background is not discussed because of the common availability of source information.

I. Systematic Descriptions of Bioenvironment.

Systematic data are available for various regions of the world on gross and fine structure of the flora, fauna, mineral, topographic, other geological, climatological nature of the environment. Where additional structural detail was needed, specific classification systems were set up for vegetation and for land forms (Dansereau-58) (Wood-61) (Carr-62D). These were reviewed and tested at the Waterways Experiment Station (U.S. Army Waterw. Exp. Stat. -61), (Maxwell-62). Such structural detail may include dimensions (height, crown, stem, diameter, shape) distribution (spacing, canopy cover, arrangement) leaf nature and seasonal change. These give the analyst here some idea of background environment structure to examine more closely for detection contrast. Bio-ecology sources can also provide data on indigenous animal types, density, movements; biological handbooks (e.g. Spector-56) yield info on excretory products composition.

Bioenvironment regional studies include: Ceylon vegetation (by air) (Chapman-47), Indochina plants (Amer. Inst. Crop Ecol. -57A), S. E. Asian, Chinese and Formosan plants and agricultural practice (Amer. Inst. Crop Ecol. -57B), comparison of S.E. Asia with Hawaii (Chambers-61) and other S. E. Asia data (Meigs-QM-53).

II. Chemical Substances in Environment and Chemical Substance Transmission.

Substances in environment which may obscure the chemical signal from the concealed man include animal excreta and scent substances, plant materials, chemical products from equipment (e.g. weapons, foods, clothing).

a. Measurements in Air

Air observation for chemical particulates and vapors are made routinely; for pollutants (McCable-52) (Mallette-55) (Taber-58); for organics in city air (Jacobs-57); and biologicals (Amdur-61); and in extensive measurements in various locales by Army personnel from Dugway Proving Ground, Edgewood and Detrick, Maryland (e.g. sampling of airborne particles) (U.S. Army Biological Labs-53, 56); by A. E. C. for effluent analysis (U.S. A. E. C. Div. Reactor Devel Air Cleaning Conf. -60); P. H. S. Taft Sanitary Engineering Center.

From such sources at least two kinds of data can be obtained: archives of materials in air, and capabilities of air background measurement techniques. For information on instruments and standards and Air Pollution Handbook, see (Amer. Conf. Indust. Hygiene-62).

b. Substances from Animals

1. Excretory products

Metabolic excretory product composition and quantity for specific animals in large part is set down in Handbook of Biological Data (Spector-56) (e.g. pp. 247). One must turn to the regional ecology and animal geography studies to determine in a given locale what animals, their density and movements exist, in order to assess this total chemical pool of excreted products. Such data will allow assessing chemical interference levels of substances similar to human wastes (deposited on ground or in air), their "contrast ratios" (amount of a substance from in air in environment/total amount from all other sources), and determination of chemical products really unique to man.

2. Scent products

Animal "scent" substances are produced by many species (see description under Biosensing); in most cases, released from a specific gland into environment, onto ground, trees or into air. These substances are sensed by the chemoreceptors, sometimes in phenomenally low concentrations, and influence the behavior of a member of the same or other species, for food finding, warning, navigation, territorial marking, mating. This is a widespread communications system in nature, and has been poorly studied to date, perhaps awaiting the analytical biophysicist's approach. Such "scent" substances (many are well described chemically) may present background interference in environment, or can yield clues for selected biosensors to sensitivities to selected substances found in human chemical output.

c. Plant Substances

Plant chemical substance backgrounds in environments of interest are not so easy to find and describe. It is possible that those investigating utility of higher plants in closed ecological systems (U.S.A.F., N.A.S.A., Boeing, Martin-Marietta, Electric Boat, etc.) would have collected such products, though no descriptions of plant excretions into air have been found.

Subjective observations of flower fragrances, wood and leaf mold scents, not to speak of crushed grass and broken stems, may have their counterparts in perfumer's chemical description of floral fragrances, and the soil microbiologist and plant physiologist descriptions of processes and products of soil decomposition.

d. Chemical Substance Transmission in Air

Transmission properties of air environment. Once particles, droplets aerosol, or vapors of human products enter air, their movements in air are subject to considerable uncertainty, with mechanisms only partly understood. For analyses, see (Lettau) and other Ft. Huachuca work; (U.S. Army Chem. Corp Symposium-54) and other Edgewood, Detrick, and Dugway indexes of reports relating to dissemination and detection of chemical and biological agents, aspects of movement of substances through hungle canopy (Bendix-63); general references on micrometeorology (Sutton-53) (Geiger-57) and chapter on micrometeorology in Handbook of Meteorology. Further references on air, weather and climate include (Napier) (Gerson-55) (Stephens-52) (U.S. Smithsonian Institution Tables) (U.S.A.F. Air Weather Service Tech. Reports List-1963).

Illustrative of data on chemical substances produced from equipment, etc. are those of (Arnest-61) on submarine atmosphere contaminants. Similar observations could be made, but do not seem to be repeated for chemical products of personal equipment - from weapon lubricants, power source fuels and exhaust, clothing, garbage.

III. Physical Signals in Environment, and Their Transmission.

Detection of physical attributes and signals of man, discussed in Sections C and E, require knowledge of corresponding environmental properties. For analysis, sources are cited below on electromagnetic properties of bioenvironment, air and terrain; sound, vibration and electrical and magnetic fields of earth.

a. Electromagnetic Radiation

Many sources of data are available on space based (image pattern) and time based (movement pattern) electromagnetic properties of environment, over the spectrum from RF to gamma, for self emission, reflection and scattering, and transmission.

1. Bioenvironment properties

Faunal populations have been photographed and studied from the air (Buckley-57); and animals and plants photographically compared in visible and infrared for fall versus winter color. (Maniffen-53), maps of color regions of the world (Chambers-56), visibility in U.S. forests (Drummond-56), conditions in tropical rain forests (Richards-52), and military geography data (Mason-57), and alteration of foliage environment by chemical means (Coates-63) represent other information sources.

Spectral reflectance data are available - visible and infrared measurements include 400-650 millimicrons (MU) with some 710-900 MU, at low altitudes, for wide varieties of terrain, identified in 300 categories, set up in 11 basic types (Krinov-47) (Penndorf-56); 500-3000 MU aerial spectra for trees and groves (Martz-56); 400-1000 MU leaf and soil sample measurements (Keegan-56) and Canadian conifer spectra (Hindley-57). In extension into ultraviolet, 250-2000 MU data are at hand on rocks and vegetation and changes after root damage (Dwornik-E. R. D. L. -62).

Other animal color studies by biologists include (Pycroft-25) (Stephenson-46) (Fox-63); camouflage (Thayer-18), compare this with combat soldier camouflage study (Humphreys-62); adornment (Hingston-33), and adaptive coloration (Cott-57).

2. Radiation transmission by air.

Observation remotely (e.g. paths up to 1 Km.) of some electromagnetic radiation contrast property of humans, from radio to gamma spectral regions, requires knowledge of air transmission obtainable from the special sources of data set down by spectral region below. Other general sources include U.S.A.F. Handbook of Geophysics for Air Force Designers, Survey of Radiation in the Air (Shaw-58), and of absorption of sun radiation (Dickson-53).

In the Microwave regions air does not uniformly transmit; for absorption at 8 millimeters see (Nicoll-51); and for 8.6 mm. transmission in 3-12 mile air paths see (Tollbert-53). Other marked absorption bands exist at 1.0 and 1.64 mm., with better transmission at 1.3mm., 2.1 mm., 3.0 mm. and 1 centimeter. Chief absorption is due to oxygen (Meeks-63) and water vapor. See (Rogers-51), for solar millimeter radiation attention see (Theissing-56). These are only illustrative examples.

Infrared transmission in air is good in a few "window" regions (e.g. 1.05, 1.25, 1.7, 2.3, 3.75-4.25, 10 microns (U)). For the good water absorption data 1-10 U see (Wyatt-62); and 0.8-1.3 U (Schotland-62A), 0.4-2.3U for long air paths (Knestrick-61) and in near I.R (Howard-50); and far IR (Elasser-38) (Cowling-43). For CO_2 in near IR see (Howard-50). For other IR data, to 1U see (Bayley-62); to 3U (Curcio-61); and others (Howard-G.R.D.) (Elder-53); (Hilsum-48); (Dunkelman-52) (Larmore-56).

In the visible region air is a good transmitter. See the atlas of air absorption, 5400-8520A (Curcio-55); scatter data of 0.4-3 microns (Curcio-61); long path data 0.4-2.3U, (Knestrick-61); the good study of 30-10,000 Angstroms (A) absorption coefficients (Bayley-62), also others on air attenuation (Deirmenjan-52) (Stewart-52); slant visibility (Goldberg-52); and contrast reduction (Duntley-48); visibility biblio (Weiner-52A).

In the ultraviolet air transmits moderately well to 3000 A., below which ozone if present will absorb (2200-3000 A.). Transmission is poor below 2200 A. due to water, O_2, CO_2, N_2 absorptions. Data from 100-3000A. are given for these substances in good studies (Holland-62); and from 30-10,000 A. (Bayley-62). See data on scatter in the middle UV (Ban); extreme UV properties of oxygen (Aboud-55); water vapor (Watanabe-53A); (Johannin-Giles-54), and other data on specific gases (Watanabe-53B) and air (Hilsum-46), (Dunkelman-52).

In x-ray and gamma regions, air is essentially opaque, unless extreme energies are involved, as at 10^{-4}A.(for 100 MEV gamma). See x-ray mass absorption coefficients information (Allen-52), and the various special weapons effects handbooks for much more comprehensive data in this region.

3. Radiation properties of terrain

For low frequencies see radar reflection data on natural surfaces by (Cosgriff-Ohio State U.) and (Newbry-60), (Kinsman-62) illustrative of vast number of available reports. For terrain responses to 8 Kmc., see (Morrow-62).

For infrared properties, see 1-6 micron spectral emissivity (Fredrickson-57), showing radiation below 3U chiefly reflected sunlight, and that from 3-6U thermal emission. His observations of rapid minor fluctuations in surface temperature can offer a possible factor of contrast relative to man. For contrast "washout" by IR background, see (Fredrickson-59). For other IR data, see the infrared symposia (IRIS) periodicals sponsored by Navy; also specs on proposed IR spectrograph devices for lunar and planetary soil composition analysis (Lyon-63).

For other spectral background data, see (Vanderhei-56); desert spectral reflectance (Ashburn-56); Nevada test soil reflectance (Hillendahl-58), the Project Michigan literature, and Project SATAN data (Sensors for airborne terrain analysis).

4. Other sources of data

Other environment radiation is described including sky background radiation measurement (Graboski-61); infrared (Bell-56); radio noise from chemical explosions (Cook) (Kosky-54) (Takakura-55); jungle radio communications (Ambera-62).

Properties of materials versus radiation will be helpful in assessing environment or human artefact emissivities etc. Some sources include: materials emissivity and reflection (Pratt and Whitney-60) (Weber-59) McDonough-60) (Hosmer-53) (Beltran-61) (Blau-58) (Holladay-60) (McMahon-50) (Gordon-56) (Bell); (Crowley-59). Additionally, on IR properties (Maki-60); 4-13U (Wood-60, 62), 2-15U (Reid-59); on microwaves and water (Posener-53); on UV and x-ray (100-1500A.) (Fivens-63); visible region (Barber-63) (Pyrne-54).

Other data on measurement techniques include: reflectance (Dunkelman-60) emissivity (Cairns-60) (Harrison-60) (Bell-55); source (field black body) (Larocca-58); other (Schotland-62A, B).

b. Sound and Vibration, Background and Transmission

For earth surface natural background acoustic noise see (Wescott-63); for other human-generated environment noises see (Bolt-52); also close quarter ship board noises (Bishop-53), and weapon noises (Doelling-59). For animal sounds see (Lanyon-60); and especially for insect sounds (Pierce-48). Air absorption in low audio ranges is discussed by (Nyborg-55) and by (Horiuchi-57) who also considers humidity effects, ultrasonic absorption (over 15 Kc/S) by (Herzfeld-59); for other air and components data such as oxygen, see (Kneser-33), for effects of temperature and water vapor on N_2, O_2 air absorption, see (Knudsen-53). For Audio Sound transmission and reception under combat conditions see (Waring-46).

For earth seismic background environment and geography see (Griffin-63). More general data are available in a vibration and shock environments biblio (Hercules-62); in the Shock and Vibration Symposia reports from the Naval Research Lab, The University of Michigan's Project Michigan work on combat surveillance (especially on seismic signatures of human devices). For other related data on acoustic sources see biblio of (Thurston-59); data on underwater sound background study techniques (Marsh-61) (Barber-62) and work of Melpar on personnel sensing.

c. Electrical and Magnetic Field Background Phenomena

If any electrical and magnetic attributes of man are to be sensed remotely by non-radiative methods, the sources below will provide some data on natural earth background conditions. Also worth looking into are possibilities that detection might be accomplished by man's distorting these electric and magnetic patterns of natural origin or others deliberately induced in ground and air.

1. Earth currents

Signals measurable vary from 10 MV./Km. at low latitudes to 400 MV./Km. at high latitudes and are measured over a bandwidth from d. c. to radio frequencies; average values on which various pulsations are superimposed (Ward-O. N. R. -62) affecting magnitude, direction and sense, with low frequency variations (under 1 C/Sec.) highly correlated with geomagnetic disturbances (Ungstrup-62) (Hessler-59) (Linehan-61) (Fleming-39), also changing with season, temperature, humidity, lightning, etc., and in presence of industrial devices, underground water.

Earth currents are typically measured with electrodes placed in ground, in North-South or East-West pairs, in one measurement 1000 feet apart (Fleming) (Hopkins-60). Proper electrodes must be chosen to avoid contact potential, polarization (Law-59) local effects.

2. Electrical Resistivity of Earth

This is separately measurable and contributes negligibly to earth current measurements. Typical resistivity measurements can be made with a known current applied to outer pair (100 feet apart), and EMF measured on inner pair, with electrode commutation to compensate for polarization, etc. A nominal value of 5 million ohm-centimeters (Fleming) may vary widely with moisture and other surface conditions.

3. Air-to-Earth Current

This is measured along a vertical line, between plate on ground and plate on horizontal wire above (Kasemir-51) or pair of horizontal plates in air. It is about 3×10^{-16} amperes/CM^2 close to ground, requiring sensitive electrometer equipment (commercially available.) This current varies with height (Chalmers, p. 142) (Schonland-53).

4. Other Air Properties

Air ionization (Israel-51) about 1. 8 ion pairs/cc/Sec. close to ground, chiefly derives from ground radioactivity (K^{40}, radon gas) (Schonland-53), with contribution by cosmic rays (Chalmers-57). This varies rapidly with altitude. Charge separation in air can be found after rainstorms and various atmospheric disturbances (L. Smith-59) (Friberger-61). Also as of this date, intense air ionization may be induced remotely, in a small volume of air, briefly, by a pulsed laser beam (see popular account in July, 1963 Scientific American).

5. Geomagnetism

Classical data on steady pattern (Fleming-39) (Rooney-49) are augmented by new studies of origins, fluctuations (Law-59) (Miles-62). For details of rapid changes of a few gamma (10^{-5} gauss) occuring with periods of o.1 sec. to 10 minutes, see (Provazek-61), and the elegant work of (Linehan-61) with proton precession and other magnetometers, getting background data for Air Force, in very sensitive fixed field measurement arrays which could lend themselves nicely to experiments on disturbances induced by presence and movements of man near the sensing elements.

E. SENSING AND DETECTION OF HUMAN ATTRIBUTES

I. Introduction

This survey of specific techniques for sensing the concealed man by means other than the unaided senses, is based on consideration of those human signal properties previously discussed(emission, reflection or its transformations, influence or proximity effects). To be observed, such signals must cross the intervening space to the observer, and not remain confined or in the vicinity of the body of the target.

First emphasis here considers the specific physical or chemical variables to be sensed, and the description of various principles of physical, chemical, or biological nature for doing this. Both passive sensing and active means(after illumination of the target)are considered. Special attention is paid to the problem of measurement of very low levels of signal, and trace quantities of material from humans.

Source data given here(and also available from many commercial and military surveillance study sources), must be further examined in a systems analysis for each phenomenon which could provide a data link, to adjudge: whether a physical possibility for use of the sensing effect exists; and what prediction can be made at present or for near future conditions about sensitivity, response time, specificity, other acceptance or discrimination properties comprising figures of merit. Further analysis of signal separation from noise(chemical, physical, or biological) and of recognition techniques, can consider methods of using intrinsic properties of the primary sensor or auxiliary devices to allow: pattern recognition, in space (radiation image), in time(eg seismic signature), for concentration(multi-substance concentration profiles), in relation to reference patterns stored within the instrument; and to allow synchronous detection(as with active systems), autocorrelation analysis, etc. Even in exploratory analysis of principles, the reader must keep in mind the ultimate problem of the use in the field action environment, and related factors of use burden(power, size, weight, mobility reduction, attention diverted from other tasks, etc.).

The material which follows will cover Biosensing(use of living material as transducer for various variables), Physical sensing, and chemical analysis methods.

II. Biosensing(Living Tissue as Detector).

a. General Comments.

The serious consideration by anyone of the use of living material as a sensing transducer requires demonstration:that specific variables can be sensed, that reproducible and stable input/output relations exist, that output signal can be conveniently collected, that the material can be kept alive and functional without inordinate effort. Only then can biosensing techniques be considered seriously for comparison with other chemical and physical instrumentation. using measurement engineering criteria of range, bandwidth, sensitivity, bandwidth, resolution, etc.

Demonstration of plausibility and utility has been carried out by many. At this point in time much is known about the living sensing process. A great deal of physical and engineering insight is being applied to describe quantitatively the transfer characteristics, internal mechanisms of the biological communication process and of sensors;and to apply knowledge obtained from observation of the living sensor process to physical design.

For general and good references on this, see:record of First Bionics Conference, Dayton, 1960, in Report # USAF-WADD-TR-60-600;also Second Bionics Conference(Bernard-62);a Third Bionics Conference held also in Dayton 1963 will be in print shortly from WPAFB. See also:Abstracts, 7th Annual Meeting, Biophysical Society, 1963;

Studies have been made on a wide variety of living receptors, sensing mechanical quantities(sound, vibration, acceleration, strain, force), radiant energy(UV, visible, IR), thermal and electrical variables, etc. They show that living receptors have many unique attributes; for some:extreme sensitivity(to quantum limits for photoreceptors)(to a few molecules of chemical substance for some chemoreceptors);they are "microminiature", are self-generating(requiring no applied power, just metabolic fuel); and have a pulse-like output, pulse-rep-rate modulation, with pulses which can be counted and stored.

Use of living material for reproducible sensing of environment is not limited to special sensory receptors;as will be described later, many types if isolated tissue may serve as transducers; and these may be employed at diverse levels of biological organization(cell batches, tissue, isolated organs, etc.).

For quite specific data usable for biophysical analysis on sensing processes, consult the following analytic studies:comprehensive book(Rosenblith-62)on sensory communications; sensory energetics(J. Gray-52), comparative survey(Bullocl-53)(Granit-55), internal mechanisms(Katsuki-61)(Kennedy-62), other biophysical reviews by (Davis-53, 61)(W. Loewenstein-59, 60), (Makarov-61);also biological signal and noise study(Molyneux-63), signal detection(Hack-63). All of this work was done as basic biological research, not applied to instrumentation. For biblio on various living sensors applicable to physical design , see(Kornfield-61)and for analyses of application to BW detection, see Kornfield-62A, 62B, 63).

For information on the ease with which sensor tissue output data signals can be collected, for specific data on the related electrophysiological measurement methods, see(Ford-57), (Bures-60)(Cameron-60)(Davis-59), and for electrodes, see(Sosnow-61). See also the description of methods in papers cited on isolated receptor preparations in the pages which follow. For the detailed physico-chemical analysis of the production of bioelectric energy and its extraction from various living sources, also see(VanWinkle-62).

For a discussion of tissue culture and living material maintenance techniques, see(Cameron-60)(Merchant-60)(Parker-61)(White-61)and the large biblio of(Murray-53);for insect tissue culture, see (Loeb-57)(Martignoni-60).

For other good biological information sources relating to sensors, for comparative physiology, including senses(Prosser-50, 61), sensory physiology(Von Buddenbrock-52); comparative physiology of the nervous system (Koshtoiants-60);insect nervous system(Roeder-58), and his insect physiology(Roeder-53);reptile sensors(Kahlman-32)chicken skin sensors(Winkelmann-61)mamalian skin nerve endings(Waddell-55), other skin nerve endings(HinChingLiu-62);bee communications(Haldane-54)animal navigation (J. Carthy);for drug use elucidating sensory process, see(Habgood-52), (Buchthal-54).

b. Specific Chemoreceptor Studies

1. Comments

The field of chemoreception is sampled in detail over the next several pages. There is included information on many specific studies on whole animal behavioral and electrophysiological measurement, and in isolated preparation electrical output studies. About 25 species of insects, and about 50 other animal species are included, where specific information was published, describing a receptor structure, and/or its sensitivities have been published. Other detailed sources are listed for data on dog smell sense and tracking, human smell and taste sense, and smell and odor information.

Chemoreceptors have been highlighted because of their phenomenal sensitivities and specificities, and multi-substance analysis capability, without counterpart in any physical apparatus today. We have set down the specific chemical substances used as stimuli for most of the experiments listed. From these, the reader may select those preparations for further experiment; which come from animals available and indigenous to the region of interest, with specific desired chemosensitivities, and yielding convenient experimental preparations.

For a few individual chemoreceptor electrical output measurement studies, not listed in the tables, see (Hodgson-55B), (VonBuddenbrock-55B), and for administration of trace chemical stimuli by microelectrophoretic techniques to individual chemosensing cells(Baumgarten-63).

Animal scent production and its sensing deserves some comment. This is a "scent communications system";a large number of species produce specific materials(in many cases chemically identified;eg. for beaver, over 100 substances--see Hardy-48), which are synthesized, stored, and released from a specific gland structure, so liberated into air environment, or deposited in environment, there to be sensed generally by the same species, with attendant behavioral response, related to food finding, warning, territorial mapping, navigation, sex, etc. The scent mechanism has been best studied in insects, where phenomenal sensitivities to known substances have been found(eg .30 molecule threshold to specific substance in cockroach sensing). The airborne substance has been identified , and chemically synthesized, the chemoreceptor properties related to it studied and the whole effort exploited in the development of insect attractant insecticides, discussed elsewhere in this report. The products of animal scent glands have also been studied by the perfume chemist and industry, to obtain components for their blends, from such animals as beaver, civet cat, muskrat & shrew, although in their case without knowledge of the animal sensors. Except for these classes of studies, the literature of ecology is devoid of accurate description of the scent communication process.

In the chemoreceptor lists which follow, of insects and other species, we have included additional data on the existence and description of scent production for many species, for several reasons: it represents a chemical substance acting as "noise" or unwanted signal in the environment to which the animal is indigenous; also from the presence of a scent organ in a species one may confidently predict that a specific chemoreceptor responsive to that substance exists in that species, even though no explicit information has been set down on chemoreceptors for that species; finally in many cases the scent substance chemical components from a given animal may have their counterparts in some product of man(sebum or apocrine gland componentproduct--which have been claimed to be types of "scent communication" substances--See Schaffer-37, Wheatley-51). Experiments with the chemoreceptors of that matchup species may be most profitable in quest for a human detection element.

2. Insect Chemoreception

Many good quantitative studies on a diversity of species, sampled herein, show the unique eligibility of insect chemoreceptors as controlled isolates for biosensing, because of experimental convenience (of hardy preparation, ease of individual receptor isolation, exposure to stimulus and single nerve response signal collection). The readers' selection of one or more insect tissues as experimental candidates for human substance sensing can derive from consideration of regional habitats of specific insects, their attraction to human hosts, and the match-up between the diverse sensitivities studied and human products. Specific receptor studies also including notes on scent substance emission are set down below.

The most promising of these for further work from the standpoint of knowledge of stimuli, isolation and measurement procedures are preparations of the silkworm moth, blowfly, butterfly and bee.

Chemoreception in Specific Insects

Ants: For direct study of olfaction, see (Marcus-46). Other studies in response to scent substances are cited below.

Scent production by various glands (Wilson-59, 62), with chemical factors catalogued (Wilson-58); produces alarm and digging behavior in various species (Wilson-58).

Bees: For early study on chemosensing by antenna and tarsus see (Marshall-35); for taste perception (VonFrisch-34), chemosensing in general (VonFrisch-50); behavior in distinguishing companions (Kalmus-52), smell sensing (Gubin-57) (Schwarz-55) (Ribbands-55); and a definitive paper on isolated antenna electrophysiological chemoreceptor measurement see (Boistel-56).

For scent glands, see (Frings-44) (Gary-62). For specific known products of queen, serving as attractants see (Gary-62). For attractant test methods see (Woodrow-58); for Bumblebee scent trail description see (Wynne-Edwards-62), and for good recent data on scent substances from bees see (Jacobson-63A).

Beetle: For early beetle olfaction, see (Richmond-27), also olfaction affecting host selection and oviposition (Crombie-41). In other behavioral studies quite early the very high sensitivity ($1:10^7$) to skatole demonstrated by (Abbott-27). For carrion beetle orientation to odors see (Dethier-47C).

Butterflies: For specific receptor studies; leg, sugar sensitivity see (Anderson-32), tarsa receptor to sucrose sensitivity by neural fiber electrical measurement, and in same (Takeda-61) receptors stimulation by electrical current to examine receptor internal mechanisms (Morita-59).

For scent emission and sex attractants isolated by (Inhoffen-51), see (Butenandt-55) (Gotz-57).

Cockroach: For early taste threshold studies on electrolytes and sucrose and the related receptor locations, see (Frings-46A). For diverse studies on cockroach chemoreception see Q.M.R. and E.C. Natick list of publications.

For scent substance sex attractant sources, see (Wharton-57), working over several years; for composition, see (Wharton-61), and effects of radiation and other noxious stresses, identification of one substance as 2-hexenal (Roth-56) and from a tracheal gland, paraquinone (Roth-58). Phenomenal 30 molecule threshold sensitivity (10^{-20}gm) of roaches to their own chemically identified scent substance is discussed by (Jacobson-63A).

Flea: Sensor physiology (Dethier-57B).

Flies:

Blowflies: Much exact work on in put/output relation, specific sensitivities, internal mechanisms has been done on these, chiefly because of their experimental convenience of access. For early chemotropic behavior studies, see (Hobson-32) (Abbott-38) (Craff-45). For other response to specific substances, for alcohol series, see (Dethier-47B), aliphatic aldehydes and ketones (Chadwick-49), (Dethier-54), various carbohydrates (Hassett-50) (Hodgson-56, 57), organic sulfur (Cragg-50B). For properties of specific receptor sites, for tarsal receptor sensitivities see (Chadwick-47); for various contact chemoreceptors, see (Dethier-55), and olfactory receptor types and responses (Dethier-52). For recent precise sensor observations including electrical output signal measurement, on labellar receptor responses, see (L. Brown-62), for water taste (Wolbarsht-57) (DeForest-61); protein (Wallis-61), NaCl (Wallis-62), and for temperature effects on receptor mechanisms (Dethier-58).

It is seen that even where extensive studies have been made on a given species, systematic exposure to all major chemical groups for threshold study has not been done. Along with such experiments can be tested thresholds to fractions of sweat, sebum, urine or feces of humans in isolated preparation studies.

Flesh fly: For smell sense see (Steiner-32); for taste, sucrose threshold see (Frings-54).

Fruit Flies: for chemoreception see (Begg-46), response to animal excrement (Harrison-54); and to fermenting banana products (Reddle-63). For scent output (male sex attractants see (Ripley).

Horsefly: for contact chemoreceptors (female) see (Frings-46B).

Sawfly: For scent substance production and chemosensitivity, see (Coppell-60) and (Casida-63), and especially rapid response of pine sawfly to nanogram sex attractant levels (Jacobson-63A).

Screw worm fly: For early chemosensitivities, including urea, see (Abbott-28). For an account of scent production and sex attractant studies, see (Jacobson-63A, B).

Walnut husk fly: For scent substances and their properties see (Barnes-58).

General comments on many other fly studies: For olfactometers, see (Eagleson-30), for responses of slies to cattle dung and urine, see (Chorley-48).

Grasshoppers: For antenna and flagellum receptors see (Slifer-55, 56).

Locust: For specific recording in nerves from in antenna chemoreceptors, see (Uchiyama-56).

Louse: For early chemoreception studies see (Pick-26), later (Dethier-57B).

Milkweed Bug: For recent atenna and flagellum receptor data see (Slifer-63).

Mite: For chemoreceptor electrophysiological studies, see (Elizarov-62), for clover mite humidity sensor, see (Winston-62), other studies (Dethier-57B).

Mosquitoes: For chemoreceptors in yellow fever mosquitoes, see (Frings-50) (Owen-61, 63), for their antenna and flagella organs (Slifer-62), for mosquito antenna sense organ survey, see (Stewart-63). For other chemosensitivities in general (Willis-47), amino acids (Schaeffenburg-59), odors attracting for oviposition (Crumb-24) and attraction by odors of Anopheles to animals (Podomodvinov-42). Chemosensing attraction to humans has been studied by many (Rahm-57A, B, 58A, B) (Laarmans-55, 56); with specific chemical factors considered by(A. Brown-56), those components of sweat (A. Brown-51, 61B) (Thompson-55) (Owen-63), including lysine at low concentrations (Brown-61B) and other amino acids (Brown-61A). Attraction by human CO_2, etc. is considered by (Willis-48) (Reeves-53), and temperature and humidity influences by (Smart-56).

Moths:

Gypsy moth: Best chemosensor studies done in relation to its scent substance (female sex-attractant), "gyptol" isolation (Acree-53), composition analysis by chromatography (Acree-54), subsequent synthesis of fractions, and use in "attractant" insecticides such as the Department of Agriculture's "gyp lure". Male chemosensing thresholds of 10^{-13} gm. stated by (Jacobson-63B).

Silkworm moth: Receptors of larvae intensively studied, measurements of specific chemical stimulus by (Morita-59B), and electrical "generator potentials" measured by (Morita-59A) (continuous E.M.F. produced intracellularly in response to the chemical stimulus, and giving rise to the spike impulse output signal train seen on the receptor nerve). For carbohydrate sensitivity, see (Ishikawa-63), and for citral, lenalyl, terpin compounds see (Hamamura-61). Good isolated antenna preparation studies with various chemicals and with electrical output measurement, bu (Schneider-57), including exposure to one kind of scent substance emitted by this organism (Schneider-56).

For other scent substance description see (Seguin-54), and series of papers by (Butenandt-47, 62) who has defined its sex attractant function, its chemical nature.

Other Moths: For comparison of olfactory specificity of emitted-scent; sex-attractants in different species, see (Schneider-62), with further isolation by (Kecker-58) and bioassay of synthetic scents by (Block-60). For giant saturnid moth sex attractants, see (Rau-29) (Dethier-47A), early references in insect scent.

Tick: For smell and attraction to animals see (Philip-53), on chemoreceptor function see (Dethier-57B).

Tropical Water Bug: For male scent substance composition, see (Butenandt-57). Since this is used by some in S. E. Asia as a food spice this scent, if carried by a native of the area, may be detectable remotely in extremely low concentrations, its analogue of isolated chemosensing preparation from this insect.

Other Data Sources on Insects: For excellent annotated biblio on smell in insects, see (Hocking-60); for comparative physiology (Frings-48); receptor ultrastructure (Dethier-68B). For chemoreceptive behavior studies see (Brown-28) (Ingle-43), (Dethier-57A) also in parasitic insects (Thorpe-37, 38, 39). For electrophysiological measurements, see (Chapman-53) (Roys-54), Takeda-59), for internal signal conversion (from chemical imput to electrical output) see (Hiromichi-59) (Morita-59A), and for other mechanisms (Dethier-48, 51, 56A).

On insect scent and attractants, see excellent recent reviews (Jacobson-63B) (Karlson-50), and older material (Cattreau-05) (Kettlewell-46). For specific receptor loci and sensitivities (Schwink-55); for certain specific attractant classes (e.g. amines, fatty acids, sulfides, NH_3) see (Green-60B).

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3. Chemoreception in Various Other Animals

To the sample of specific studies cited below on chemosensing, scent production and communications, apply the same criteria cited under "Insect Chemoreception" to select hardy tested preparations for further experiment in sensing human chemical products.

Promising animal chemoreceptor preparations considering only the superior knowledge of tissue isolation, measurement, and understanding of some stimulus properties will be seen under Cat, Crayfish, Hamster, Rat, and especially Frog and Rabbit.

Alligator: For olfaction, see (Gestland-61). Scent glands "musk" secretions see (Foster-34), (Hardy-49A).

Anteater: For taste receptors see (Kubota-62).

Arthropods: For chemoreceptors terrestrial and fresh water forms, see (Hodgson-58B).

Badger: For scent glands close to anus, in some, in a pouch under tail, see (Hardy-49A) (Neil-48).

Beaver: For scent glands between anus and genitals see (Schweisheimer). For composition of products of this "perfumery animal" see (Walbaum-27) (Rosenthal-28) (Lederer-43) (Naves-34, 47) (Givaudan-49) (Arctander-60), for 100 constituents identified see (E. Hardy-48).

Birds:

Condor: Smell (Gill-04).
Duck: smell (Nolte-30) and scent production (Bang-60).
Gray Goose: smell (Best-13).
Ostrich: taste and smell (Gillespie-22).
Quail, Bob White: chemosense discrimination (Frings-52).
Turkey, Wild: smell (Caton-70).
Vultures: chemosenses (Bang-60) (Leighton-28) (Lewis-28). Scent gland and "musk" production musk glands (Bang-60).

For other general data on taste and smell see (Portman-61) (Soudek-29); smell (Zahn-33) (Taverner-42) (Miller-42) (Bartsch-43) (Bang-60); for conditioned reflex studies see (Walter-43).

Boar: For scent glands and products see (Pocock).

Cat: Taste fibre response spectra (Cohen-55). For scent substance composition from civet cats see (Bennett-29) (Hardy-47A) (Naves-47) (Treatt-12) (Vandenput-37) (Arctander-60) (Bedoukian-51) (Dubois-59). For relation between scent production and sex behavior see (Stoller-61).

Chimpanzee: Smell (Blackman-47).

Crabs: Smell and taste receptors in mouth in one species (Cheesman-22); in horseshoe crab chemoreceptors (Barber-56).

Crayfish: Chemosensory responses to NaCl, glycine, glutamic acid (Hodgson-58B).

Crustacea (various): For chemoreceptors (Laverock-63); for scent substance and sex attractants (Forester-51).

Deer: For common deer smell sense see (Caton-70). Musk deer furnish an important source of perfume components. For scent glands, in musk deer, between naval and penis see (Naves-47). For those near eyes, hocks, toes, see (Stoller-62); for secretion see (Durvell-23) (Perry-25) (Sagarin-45) (Naves-47) (Bedoukian-51) (Schweisheimer-56) (Wynn-Edwards-62) and (Owen).

Fish:

Carp: For taste see (Konishi-61).

Salmon: For smell and taste sense, see (Hassler-57); and for repulsion by human skin serine see (Idler-55).

Other fish: For discrimination of stream odors see (Hassler-51).

Fox: For scent glands on feet, pads, near anus, and products, see (Mivart).

Frogs: Experimental convenience, including sensory access, has spurred much receptor work; on taste receptors, single unit studies (Kusano-60) (Casella-61), including response to NaCl and sucrose (Kusano-60). Acetic acid (Kimura-61B). On smell receptors: olfactory nerve signal collection (Kimura-61B), receptor system microanatomy (Altner-62) response to cations versus anions (Yamashita-63).

Goat: (Alpine) For scent gland and products see (Bedoukian-51).

Hamsters: These provide convenient preparations allowing good receptor studies for taste receptor, microelectrode measurement, see (Kimura-61A).

Invertebrates: for chemoreceptors in general see (Hodgson-55A).

Jackass (Laughing): For taste and smell receptors see (Pocock-12).

Lion: For smell see (Oliver-30).

Martin: For scent glands (anal) and dispensing of secretion on twigs, see (Portman-61).

Mouse: For olfaction detailed behavioral and physiological studies, e.g. smell induction of neurohumoral changes affecting estrus,etc. see (Parker-61).

Nereis: For chemoreceptor responses to alcohols, see (Case-62).

Newt: (Spotted) For smell sense see (Copeland-13).

Opossum: For study of isolated olfactory epithelium, recordings on isolated nerve and essential-oil stimuli, see (Beidler & Tucker).

Rabbit: Many good olfactory studies for "electro-olfactogram" (recording in olfactory nerve tracts), see (Moncrieff-61); for study of sensor smell and taste enzymes, see (Varadi-51), for anal scent glands see (Owen) and for relation of scent production to sex activity, see (Cougard-47).

Rat: For taste receptor microelectrode studies, see (Kimura-61A).

Scorpion: for chemoreceptors, see (Alexander-57).

Sheep: For scent gland location and output, see (Hardy-49B) (Bedoukian-51).

Shrew: For lateral scent glands and territorial mapping behavior, see (Pearson-46).

Skunk: For scent glands and substances, in U.S. and European polecats, see (Hardy-49A, B).

Snake: For "olfactory" cells on tongue, see (Smith-51); for anal scent glands also see (Smith-51).

Spiders: For chemosensors, see (Abbott-27).

Toad: For direct electrical measurements on olfactory epithelium, see (Takagi-60, 61).

Tortoise (American): For scent glands see (Hardy-49A).

Turtle: For mud turtle chemosensors, see (Carr-51) (Poliakoff-U. S. S. R. -30); for musk turtle ventral scent glands, see (Risley-33).

Viper: For smell sense, see (Bauman-27, 28).

Weasel: For scent gland substances produced and "musking" scent deposition behavior, see (Neal-48).

Whales: For smell sense, see (Kellogg-28).

Wireworm: For chemosensors, specific stimulus studies, see (Crombie-47).

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4. Dog Chemoreception

Dogs have proven invaluable in intrusion detection, tracking, and other observation of humans, are currently under laboratory and field study, and use for special operations, by various Defense agencies. Since our primary concern was with basic sensing processes, we have assembled here a small fraction of published material on dog tracking of humans and related subjects as a source for further analysis by the reader in our context of discussing biosensing by whole animals and isolated preparations. Most of the published work, though emerging from the pen of dog handlers of proven capability, is inexact and only generally descriptive, where factors of specific human attributes, environmental modifications of these and precise conditions of dog response are concerned. Most of the references were available and seen in the New York and Boston Public Libraries, ard are probably in the Library of Congress.

For specific comments on human tracking (Budgett-37) discusses ranges, loss of track with time, masking by vegetation (e.g. by mint, willows), and enhancement by vegetation, in grass. Tracking on crushed vegetation trails is also discussed for bloodhounds by (Whitney-47, 55). (Dr. Whitney, an outstanding authority on dogs, is in Orange, Connecticut.)

For detailed discussion of skilled tracking (including New York State Police work) on new and old trails (100 hours) and long distances, see (H. Davis-56). He expresses conviction that dogs pursue traces of skin products, reaching the ground diffusing through shoes, etc., and speculates on specific chemical substances involved including such fatty acids as caproic and propionic. He describes tracking experiments using traces of known substances deposited on ground including acetic acid and salt. For similar experiments with deposited chemicals, (e.g. iso-valeronic acid) and tracking responses similar to those for humans, see (Budgett-37).

Major L. Davis of K-9 Training Agency, at Hyde, Maryland (near Baltimore), who has trained dogs for many diverse tasks, and did work on CW detection by dogs, suggests in conversation that the skin product sebum is the key factor in the tracking of man.

Simple, but definitive experiments could be conducted by any of these good dog tracker trainer groups cognizant of the chemical factors problem, using sebum of man deposited on ground or dispersed in air in various concentrations. Sebum used could be freshly obtained, from various people, or allowed to undergo normal skin bacterial decomposition, and could be used whole or in fractions obtained by chromatography (mentioned elsewhere in this report) to define exactly which chemical factors, if any, from sebum are the key ones in human tracking.

For other studies on human tracking, see (Schmid-35), for human individual differences (Kalmus-55), and for dog breed capability differences, see (Schnitzer-62).

For other smell sense descriptive writings, see (Grassi-89) (Romanes-87, 90) (Binet-96) (Johnson-14) (Henning-19) (Bozelli-21) (Buytendijk-21) (Rudolph-23) (Warden-28) (Cramer-41), and for hounds (Rudolph-23) (Whitney-47, 55). For conditioned reflex studies on smell and taste, see (Allen-37) and for direct electrophysiological measurement of chemoreceptor (taste), see (Anderson-50).

For other general discussion of military uses of dogs, see (Meguian-20) (Going-44) (Behan-46) (Gorman-54) (Downey-55) (Waller-58) (Derringer-58) (Clapper-61), including study for certain CW agent detection (Davis-62). General narratives on police uses include (Diederich-09) (Gross-12) (Craig-24); utility of hounds (Knoche-57) (Chapman-60), and smell sense (Lohner-26) (Schmid-35).

For descriptions of dogs, by type, for hounds, see (Sigling-28) (U.S. Lib. of Cong., Div. of Biblio.-26) (A. Smith-32) (Chapman-33) (Stancko-54) (Watts-55); and bloodhounds by (Oliphant) and (Whitney-47, 55) (Appleton-60); beagles (Denlinger-56); Doberman Pinschers (Denlinger-53).

For other general related discussions of dogs, see (Menzel-29, 30) (Mason) (L. Whitney-33) (Lyon-50); also dog encyclopedia (H. Davis-56); and animal behavior descriptions (J. Scott-58) (Dorn-57).

5. Human Chemoreceptors

Human smell and taste sense data likely will provide very little direct contribution to solution of the human detection problem. But the reader may find the few sources cited here of value, in considering human thresholds compared with animals having special sensitivities, factors modifying smell sensitivity (and possibilities of enhancement of human olfaction), and what little data there are on human smell perception of other humans.

Olfaction: For nose structure and function, see (Holmes-49) and Proetz's "The Nose", about 1954. For many threshold values see (Spector, p. 327-56), (Hessel-61), (VonSkramlik-48), for mixed organic chemicals (Rosen-62); absolute intensity judgment (Engen-59), threshold theory (Davies-55), olfaction information processing (Wright-63), and other odor evaluation (Merritt-59, 60, 61); (Crocker-52), (Amer. Soc. Perfumers-61). For "chemical analysis" by olfaction, see (Alekseevki-41). For multiple factor smell analysis, see (Hsu-46) and especially (Schutz-61). Using many human subjects and odorants the latter's multiple factor studies isolated 18 physico chemical variables associated with human olfaction most classically suggested, including radiation spectra, surface activity, vapor pressure, boiling point, heats of combustion, refractive index, etc. For odor versus composition see (Timmermans-54). For devices for presenting odor experimentally, see (Wenzel-48, 50), Battison-62).

For factors altering olfaction sensitivity and capability, drugs (e.g. menthol, strychnine, acetylcholine), see (Skouby-54), for industrial substances, (Eolian-60). For suggestive relationships to various sexual factors, to sexual activity (Podolsky-46), olfaction changes in conditioning with androgens and estrogens (LeMagnen-49) and relation to female secondary sex characteristics (LeMagnen-48), smell sensitivity to sex hormones and their metabolites (Klock-61). For defects in smell sense after injury, see (Leigh-43), changes with temperature of the odorous substance (Kerka-56), changes with altered physiological state (LeMagnen-50).

For human smell sensing of other humans; for geographic regional odors, for Europeans, see (Adachi-03) (Laloy-04A, B), for several groups, including Japanese, French, Balkan, see (Eller-41), for human odor individuality, see (Laird-35); (Lohner-24). For other human odor sensitivities, significance, and control, see (Haggard-41) (Neuhaus-61); for human "scent-producing organs" see (Schaffer-37); and for the production of odorants on skin in normal bacterial flora there, see (Strauss-56). On other odor problems related to man, on odors and shelter habitability see (Muraoka-61) (Traffalis-55); sanitary significance of odors (Earp-23); their detection in water (Fair-34); odor control (McCord-49); especially in (casualty) evacuation aircraft (Gee-51); various others including breath garlic odor (Haggard-35); fish odor (Mangan-59), and asthma induction by urine, feces, sweat (Vamis-47).

Taste Sense: : For basic concepts see (Johnston-55); chapter in Handbook of Neurophysiology (Magoun-61), Handbook of Experimental Psychology edited by S. Stevens in 1951; for compound evaluation techniques and flavor research, see (Krum-55) (Peryam-58); (Merritt-58, 59, 61), and for flavor physical chemistry see (Laymans-59). Information on human taste sense will probably contribute very little to selection and trial of other animal isolated smell and taste receptors, with human chemical products.

6. Other Specific Studies

For excellent biblio. on smell and odor, see (Airkem-52); for theories of smell, see (Jones-O. N. R. -53) (Foster-50) (Kluvier-58) (Beidler-57, 60, 61A); for enzyme theories (Kistiakowsky-50); other analyses (Middleton-56) (Mateson-44) (Bedichek-60) (Bronshtein-U. S. S. R. -50) (Beets-61) (Dravnieks-62) and new identification of physical variables (Tucker-63). For studies of smell epithelia (Baradi-57) including electrical activity of isolates (Ottoson-56); and of smell adaptation (Adrian-50). For regeneration of olfactory cells, see (Schultz-41), and old papers, on scent (Shepherd-Walwyn-26) (Bawden-01) (Hopkins-26).

Taste Sensors: For analytical papers on contact chemoreception, see (Beidler-54, 57, 60, 61A, 61C) (Bronshtein-50) (Roshupkina-54); for comparative description (Johnston-55); electrophysiological studies (Beidler-55A), on single fiber signal output (Zotterman-59) (Sato-60) (Kimura-61C), other measurement techniques (Hodgson-61). For physical chemistry (Ruben-62) including enzyme basis of taste (Koshtoiants-58) (Mateson-54); for CNS efferent control of sensor (Esakov-61); taste and smell enzymes in rabbit (Barack-5).

Interochemoreceptors: Within higher organisms, neural receptors have been identified, for osmotic pressure sensing in the head, for O_2, CO_2, PH sensing in carotid and aortic bodies, for glucose in liver (Russek-63). Others are suspected to exist, in the intestine (Baraz-61) and elsewhere, sensing at least those several dozen chemical variables of blood plasma known to be regulated at steady levels by homeostatic systems, responsive to stress of loading or deprivation of substances. If discrete receptors are found for high molecular weight substances (proteins, polysaccharides, etc.), amino acids, urea, these may be studied as isolated biosensing elements, to match human product output.

Other Work: For comparative physiology, see (Jahn-50) and for invertebrates (Keefe-62) and other "common chemical" senses, see (Crozier-16). For calcium relation to function (Lenhoff-59), reception in aqueous versus gas phase (Hodgson-53), for carboxylic acid cycle role in reception (Teng-61). For anatomy, (Clark-57) physical chemical factors in stimulation effectiveness of compounds (Ottoson-63),), and chemoreceptive regulation of animal feeding (LeMagnen-59). For a review of chemobiosensing in application to BW detection, see (Kornfield-62A, B, C, 63). For Air Force interest in enemy troop detection by physical analogs of olfactory techniques, see (U. S. A. F. Aerospace Med. Lab Procurement Office).

c. Chemosensing by Isolated Tissue Other than Receptors

In principle, all regions of a living organism have potential and actual responsiveness to chemical stimuli. In practice, tissue isolates have been prepared from most every organ, in many species, at levels of cell, tissue, organ, then exposed to chemical stimuli. For all tissue culture and life support means have been identified for easy maintenance of extended integrity. (Also some tissues can be kept in low temperature or chemical stored state for long periods.)

On various types of isolates, so supported, continous observation of overt response (readout) appears most practical by mechanical and electrical means, with straight-forward extensions of instrument engineering techniques. Observations on typical preparations illustrated show rapid responses and high sensitivities to wide range of known chemical substances.

Sensitivity augmentation is possible by proper conditioning of the animal from which the tissue was taken, as will be discussed. Some types of isolates include:

Living Skin: A few square centimeters, most easily obtained from frogs, can be set up as a membrane barrier in a simple hardy apparatus which keeps it alive and yields a large electrical signal change rapidly upon exposure to traces of a variety of known chemical substances. For experimental apparatus see (Scheer-60), (Ussing-60); for effects of specific trace substances, for example, for low molecular weight materials (steroids), see (McAfee-61); for response to high molecular weight substances (e.g. toxins from cholera organisms), see (Huber-60). Many other known trace chemicals also act to alter specific metabolic processes in this living skin, changing its permeability and ability to "pump" sodium and other substances across itself and against a concentration gradient, so altering observable voltages and "short circuit" currents always present and measurable.

Living Gut Strips and Segments:

Contraction events: A strip a few cm. long, from rabbit, or guinea pig ileal region of the intestine, easily set up in life supporting medium, contracts automatically, rhythmically, and will show big changes in length and force-time patterns (using simple strain gage tranducers) on exposure to trace chemical substances. For instrumentation, preparation and other technique, see (Cook-61) and any current texts on drug bioassay. For responses to specific low molecular weight substances, for histamine and histidine degradation products see (Mosebach-61), for acetylcholine, see (Cook-61). Greatly exaggerated sensitivities to specific substances approaching a few molecules of very specific stimulus, may be obtained by "presensitizing" the animal from which the tissue is taken with substances of interest using standard immunological procedure. This is classic for bacterial products studies (Schultz-10), more recently (Buckland-60).

In some simple definitive experiments, the antigenic enhancement properties of whole human sebum, or feces and urine extracts, could be examined by attempts to sensitize guinea pigs with these, then measurement of specific and high sensitivities of isolated ileal strips from these animals to such products. This enhancement procedure really could be applied to any of the living tissue biosensing studies discussed in this report.

Electrical events: For bigger flattened pieces of gut kept alive used as membrane barriers, the same rapid electrical signal changes and measurements described for frog skin above, result from applying trace chemical substances. For technique, apparatus, and measurements with specific substances, see (Vaughan-61 63).

Living Blood Vessel and Heart Strips: Strips of a few cm. cut spirally from aorta (a main vessel) of rabbit, supported in simple apparatus, change length rapidly (measurable by strain gage) on exposure to low levels of various chemicals For technique and responses to adrenalin and related substances, see (Furchgott-53) (Helmer-57) (Briggs-61).

Cylindrical pieces of artery or aorta, stoppered at both ends show changes in pressure-volume relations rapidly (by simple electrical manometer measurement) many chemicals (Remington-62).

Whole hearts, removed from frogs and toads in simple support and measurement systems, beat for long periods, show large changes in beat force, size (mechanically measured), when various steroid substances, etc. are applied. For toads, see (Naylor-57); for frogs, (Ware-57, 60).

Living Bladder: Isolated urinary bladder from toad is easily kept alive and set up for pressure-volume change measurement as a function of many different chemically identified trace substances. See (Bentley-58) (Leaf-62).

Living Nerve Tissue: From a few c.c. of brain tissue kept alive from various regions and species, but hard to maintain, self-generated rhythmic electrical signals easily measured change on exposure to chemicals. For human adult cerebellum tissue, see (Cunningham-61).

Handier neural tissue includes nerve and urinary bladder strip isolates from rabbit (Ursillo-61) changing response to electrical nerve stimulation as function of applied chemical substances, and similar preparations of frog sciatic nerve and skeletal muscle. Isolated segments of nerve may be used with down stream propogated electrical signal integrity altered by trace chemicals.

d Bioreceptors Sensitive to Mechanical, Radiant, Electrical Energy, etc.

While chemoreceptors have dominated our consideration of biosensing phenomena plausibly usable for detection of human products in comparison with other methods, the reader should consider the capabilities of several other classes of biosensors, illustrated below, for detection of physical signals and attributes of man, in comparison, again with existing and developmental physical apparatus. These biosensors offer phenomenal sensitivities, signal variable specificities, and in microminiature form can handle some very complex signal signatures (e. g. the few moth acoustic receptors handling the wide range ultrasonic FM bat signal pattern (Roeder-61). These receptors also are self-generating, requiring no electrical power, are extremely small, have out put in pulse form (which can be counted, stored and used in real time computation). The examples only superficially touch on the literature available.

Mechanical Energy Receptors:

Sound: For moth single receptor electrical measurements, and bat signature signals, see (Roeder-61); for bat sensors, see (Griffin-59); for other insect sensors, for isolated spider leg response (VanderKloot-58); and insect ear ultrastructure (Gray-58). For other hair sensilla and tympanic organs, see Prosser, "Comparative Physiology," 1951). For single sensory unit response, cat, see (Rupert-63).

Pressure: For single receptor (Pacinian corpuscle) electrical output data, see (Diamond-58) (Cauna-58), for internal conversion mechanism in these from mechanical to electrical signal, see (Loewenstein-58); for hydraulic pressure receptors (deformation receptors of carotid sinus) see (Landgren-52).

Vibration, touch: cat hind limb vibration receptors (Hunt-61), touch receptor stimulus sensitivities (Catton-62); for touch, skin space-time pattern similarities with hearing cochlear stimulation (VonBekesy-59).

Deformation, strain: Stretch receptor structure and properties compared in seven insect orders (Osborne-62); for isolates from frog muscle, see (Katz-50).

Other: Water flow reception, lobster hair peg organs (Laverack-62).

Radiant Energy Receptors:

Ultraviolet: honeybee ocellus receptors (Goldsmith-58A), their spectral sensitivity (Goldsmith-58B), and electrical output (Goldsmith-60), cockroach ocelli (Goldsmith-58A).

Visible light: From huge volumes of literature, a few illustrations: species comparisons of simple single unit receptors (Wolken-59, 60), other single unit studies (Herman-63). For specific types: squid (Hagiwara-62); crayfish and lobster isolates (Kennedy-61); planaria receptors and electrical responses (Behreus-62); mollusc "neural tissue" photosensitivity (Kennedy-60).

Infrared: chiefly described for viper (Snake) facial pit organ (Block-50); as in rattlesnake (Bullock 52, 56, 57) citing threshold IR energy fluxes at 3×10^{-4} cal. / $cm.^2$/ sec. For most recent work, see (Beichmar-62).

Thermal (Contact Temperature) Receptors:
See analytic studies and reviews of (Hensel-60, 61), major biblio. of (Shambaugh-60).

Electrical Energy Receptors: Not listed with the classical special senses, electroreception was examined early in marine forms, in behavior of catfish to metallic rods in water (Parker-17), and other response studies (Regnait-31). More recently, studies of special electrosensing organs, by (Lissman-50, 51) on Gymnarchus, relations of sensor to low level coded electrical signal emitting organs (Lissman-58A) and to object location (Lissman-58B), to interactions with other animals (Lissman-61). Electroreceptor thresholds stated by (Machin-60) as 30 nanovolts/cm. and 3 nanoamperes current differences, for received electrical pulses of 1 millisecond duration and repetition rates to 300/sec. For more recent reviews, see (Bullock-62) (Lissman-63), for direct recording of electrical output signals from this electroreceptor (amplifier, as it were), see (Hagiwara-62A). Distinguish this communications and obstacle location transmitter-receptor system from high power electric organ action systems-see (Fessard), and many papers of Nachmanson, Grundfest on electric eel in the physiological literature for 20 years. One might expect that structural and functional analogues and potentialities, for electroreception by land forms can be unearthed in the biological literature, but cursory review has turned up only these behavioral responses to electric fields: snail movement patterns changed (Webb-60); planaria responses (Brown-62); activity pattern and oviposition rate changes in flies and other insects (Maw-61); various plant responses (Andres-60). Also studied has been human sensitivity to electrical signals applied to body surfaces in coded space, time and spectral patterns, for communication (discussed elsewhere here). If significant alterations by presence of movements of man were shown to occur in natural electric field patterns of earth and air (described elsewhere here), then pursuit of terrestrial bioelectrosensing, use of marine electrosensing isolates in experiment, would be worth doing.

Magnetic Field Sensitivities:
Mentioned for completeness, a biosensitivity to natural fields, and applied artificial fields, has been claimed based on behavioral observation in lower forms (snails, planaria, protozoa) in a series of studies over many years (Brown-59, 60A, 60B, 62A, B) (Barnwell-61). No discrete sensors have been shown to exist. Again, creation of contrast in environment by concealed human alteration of earth or induced magnetic fields could spur review of known biomagnetic field sensitivities, for comparison with physical methods. For other magnetic field sensitivities, for threshold alteration in frog nerve (Liberman-59); developmental anomalies induced in fruit fly (Mulay-62); for other methods of detecting possible effects, see (Foreman-61), for plant magnetotropisms, (Krylov-60). For other biological effects, see (L. Davis-62B), biomagnetic reviews (Alexander-61, 62).

III Chemical Products Sensing by Chemical and Physical Means

a: General Comments

We seek to observe the individual and collective products of man (see Human Attributes) after passage through environment (see Environmental Modification of Signals) by continuous measurement methods with adequate sensitivity, and specificity, if they are to be useful for detection

Any system must include collecting means for obtaining within a reasonable time a representative sample of air (or water or soil) which might contain human products. Much effort has gone into the consideration of the micrometeorology, sampling statistics, mechanisms by those in the fields of air pollution and public health, nuclear energy, BW and CW (whose techniques are cited elsewhere in this report). (e.g. For methods of airborne material sampling, see U.S. Army Biological Labs-53); Such collection may be done with devices on the ground or in the air (for aerial sampling by helicopter see Gartrell-55,56A,56B).

From the large volume of air which generally has to be displaced must be totally extracted its contents of chemical product in vapor, aerosol, particle form, which may then be concentrated into a suitably small volume of liquid or gas for further separation and analysis. Extraction means, may include filtering, impingement, electrostatic precipitation, adhesion, sonic aggregation, sedimentation, thermal precipitation, condensation, etc.

Systems analyses to establish the possibility then feasibility of one or more chemical detection approaches, (considering all variables of source, background, and detection) may be patterned after the methods used by analysts such as the Chemical Operations Research Group at Army Edgewood Arsenal, Md; or with the use of a theoretical model common for both physical and chemical human attributes sensing, along lines suggested under "Physical Signal Sensing", and also carried out by many groups in the physical surveillance field.

The emphasis below will be on physical techniques for chemical analysis, which show the greatest potential for fulfilling these conditions.

Separation Techniques: Whether chemical physical or biological techniques are used for the final analysis of the human product sample, separation of chemical components will probably be required. While the reader should seek data on the various chemical unit operations for separation including ion exchange, dialysis (and other membrane processes), distillation, filtration, etc. illustrative sources are provided below on the techniques of chromatography emerging as important for separation of multicomponent mixtures of macro and micro concentrations of biochemicals, and adaptable for human product separation. Some analysts may go no further in quest for a human products analyzer than a gas or gas-liquid or paper chromatographic system with the various common detector and readout adjuncts available; others would first consider chromatography as a supporting technique, to be used with the best of other methods described in this report.

Gas chromatography sources include (Pecock-59), (Keulemans-59), (Johns-60), (Janek-60), (Giddings-62), (Symansky-62), (Purnell-62), (Varadi-63). For urine volatiles, se e(Bonnichsen-62), urine aromatic acids (Williams-61), biological amines (Fales-62), for volatile toxics in blood (Curry-62). For special techniques, for dissolved gases in sea water (Swinnerton-61, 62), microanalysis of dihydroxy aromatic acids (Williams-63), micro-system with capillary column and flame ion detector (Halasz-61) and sample pyrolysis as "front end" for gas chromatography (Hayden-63).

For other gas-liquid chromatography, for hydroxy-fatty acid microdetermination, see (Kishimoto-63); fecal neutral sterols (Wells-63) high-speed techniques (Purnell-60) and use with IR spectrometer for fraction analysis (Anderson-61).

For paper chromatography, see review of (Block-58) and for automatic readout devices, see (Parke-52), for other sources, see general reference (R. Scott), amino acid autorecording (Spackman-58) organic acid microgram determination in small samples (Reddle -63),

b. Chemical Procedures

. With limited time available, the review of possibilities for field identification and measurement of human chemical products did not consider at length "wet" chemical analysis. In looking further, the reader should examine the unique features of organic chemical microanalysis techniques related to human chemical products (Edstrom-58), (Morrison-61), (Goldzieher-62), (Henry-63) (Bawden-63) some of which are not yet convertible to physical technique. Also see data on the emerging automatic analysis systems (cited elsewhere in this paper, also see the literature on autoanalyzer of the Technicon Co., papers of Dr. Raymond Jonnard of Prudential Life Insurance Co).

c. Physical Methods

The methods surveyed here have the potential of high speed, sensitivity, substance specificity, wide concentration range, multi-substance handling, adaptation to reliable automatic unattended calibration and analysis. Each data source cited deals with capability for analysis of one or more specific chemical substances known to be excreted by man. Methods vary in degree of separation and purification required for substances in mixtures; as discussed in the papers listed under each method. Chromatography as a separation and preparation technique is the only one discussed herein, but the reader should consult papers of other separation unit operations (e.g. ion exchange, dialysis, filtration, absorption, distillation). One practical solution to multicomponent substance analysis is the composite analyzer, embodying several physical techniques each best in a different class of substances.

This is illustrated by submarine atmosphere and contaminant analysis (Nestler-58), (Piatt-60B) and various people at Naval Research Lab.

1. Radiation Spectroscopy

This offers presently most versatility, and libraries of data on substances properties are available. For organics see (Lang's "Absorption Spectra in UV and Visible Region" Acad. Press. NY 61), electronic spectral data (Ungrade), also see spectroscopy handbook (Clark-60B0, biological materials analysis (Mitteldorf-51) (Penner-59); reflectance spectrometry of opaque materials (Shibuti); and trace analysis by ultramicrospectrophotometry (Craig-53).

Infrared Absorption Spectroscopy: Illustrations are given of available data on substances found in human products. For amino acids, for cystine, asparagine, glutamine to 5 mg. sensitivities, see (Davies-53), also for cystine (Wright-37), and others (Scheidt-52). For purines and pyrimidines, for cytosine to 60 mg. sensitivities, see (Stimson-52), uracil and thymine at low levels (Locker-49). For carbohydrates, see Methods of Biochemical Analysis, Vol. 3. For steroids and other derived lipids, see (Blout-50, 53), (Freeman-53). For high sensitivity to carboxylic acids, see (Mitchell-56) (Pobiner-63).

For measurements of extremely small amounts, for 30 X 10^{-12} gms. of hemoglobin, see (Clark-60A), and for microspectrophotometry through reflecting microscope, see (Barer-59); for review on trace measurement, see (Stewart-59). For other specialized techniques, for compact IR spectrophotometer designed for automatic composition analysis of lunar and planet soils, see (Lyon-63), for IR photometry of CO_2 obtained by pyrolysis of unknown organic compounds, see (VanHall-63).

For IR spectra data collections on substances of interest here, see excellent work of (Sadtler), others of (U. S. Nat. Bur. of Standards), biblio. of IR spectra (Clark-57), gas data (Pierson-56) lipoprotein atlas (Freeman-53). For other discussion on biological materials, see (Andrasina-61); and on complex molecules (Bellamy-58).

Ultraviolet Absorption Spectroscopy: For specific classes of substances of interest such as nitrogen compounds, for amino acids, indoles, uric acids, purines and pyrimidines, see the massive spectral graphs of (Sadtler), and data of (Stimson-52). Also for purines, pyrimidines, and ribonucleic acids, see (Cheng-63). For various other organics, acetone, hippuric acid, also see (Sadtler), (Spector-56). For vitamins and such steroid hormones as estrone, androsterone, see (Loofbourow-43).

Currently, sensitivities in commercial spectrometers are claimed to 10-8 gm. for organics. For microspectrophotometry allowing very low level measurements, for pioneer work, especially on nitrogenous biochemicals (as intracellular constituents in situ) see writings over 20 years of Caspersson at Karolinska Institute in Stockholm, and more recent adaptations, the rapid scanning "cytoanalyzer" UV microspectrophotometer also good for trace substances, made for U. S. Government by Airborne Instruments Laboratory.

Colorimetry: Visible absorption measurements in selected fixed spectral bands are made on compounds of interest to which substances must be added to produce or evoke color. Simple instruments and technique for urine, feces, etc. and extensive tables on procedures and sensitivities for specific substances are prepared by commercial instrument vendors. For automatic colorimetric analysis, see (Skeggs-57); literature on the autoanalyzer by the Technicon Co., and papers of Raymond Jonnard (Prudential Life Insurance Co. in New Jersey). For other procedures data, see (Halvorson-50), (Kruse-53); (Meites-63).

For illustrative data on specific, relevant substances, data for such amino acids as glycine to 0.4 parts per million, isoleucine 3 p.p.m., and a good general discussion, see (Meites-63). See Meites also for such sugars as xylose to 30 p.p. billion, fructose to 5 p.p.m.; also for high sensitivities for arginine (Salake-58), adenine (Davis-63); lactic acid (Tfao-52), ammonia (Kruse-53).

Emission Spectroscopy:

Flame Photometry: Measurements may be made with very high sensitivity, for specific elements from biological products, to parts per billion for some elements (Robinson-61) (Gibson-63). To the frequently measured substances sodium, potassium, also calcium and magnesium handled with simple instruments, are added others observable including Aluminum, Tin, in very low concentrations. For useful data, see Methods of Biochemical Analysis, Vol. 3.

Electrical Discharge: Long used for metallurgical study, technique has special utility for biological measurement. In this, it has very high ultimate sensitivity; nanograms per liter for Aluminum, Tin, Silver, Copper, Manganese, Lead (Cholak-38), and better than part per billion sensitivity for other substances. (Author unknown, for "5 P. P. B. Sensitivity, Anal. Chem. 32: 51A, 1960), also (Methods of Biochemical Analysis, Vol. 3).

Measurements of trace minerals in urine by this technique (Lead, Manganese, Copper, Aluminum, etc.) on comparative ethnic basis (French, Mexicans, Americans, certain Mexican Indians) show significant concentration profile differences directly associated with the soil mineral distribution in the area in which the individual has spent most of his life (Kehoe-40). This could be an important ethnic separation technique ("Man ist was er isst!"). While chief measurements are on mineral elements, for organic vapor emission data, see (McGrath-61B).

Fluorescence Spectroscopy: Excitation of substances of interest by UV yields reemitted radiation for analysis of longer wave length. Substances may fluoresce directly or require chemical treatment to produce this.

Illustrating specific fluorescences of interest and extreme sensitivities, uric acid at 0.7 p.p.m. (Duggan-57), guanine at 0.1 p.p.m. (Long-61), aromatic aldehydes and acetals (Crowell-63), arginine (Conn-59). For more data on specific compounds, see (Long - Biochemist's Handbook-61), for method, see (Udenfriend-62), (Meites-63). Claims of ultimate sensitivities to 10^{-13} gm. have been made.

X-ray Spectroscopy: Ammonia and various nitrogen-containing biochemicals can be determined in submicrogram quantities (Mathies-62) who has extensively surveyed use of this technique in biology.

Raman Spectroscopy: Certain samples excited with bright narrow-band visible light re-emit weak bands on slightly different wavelengths. Effect is based on special vibration-rotation properties similar to those involved in IR molecular absorption, except that one can use visible spectral observation. Previous limited use (because its source brightness, spectral purification, detector sensitivities were not good enough), now will change with availability of very bright narrow band laser sources, ultrasensitive and synchronous detectors, etc. (see July, 1963 Scientific American for illustration of very new laser Raman spectroscopy).

For measurements on specific substances of interest on human detection, for amino acids, cystine, alanine, histidine at low levels, see (Edsall-50); for others (Nicholson-60), (Ewing-60). For related new instruments and methods, see (Mangini and others in "Advances in Molecular Spectroscopy").

Mass Spectroscopy: This technique of analysis and identification of elements and compounds by their mass offers great sensitivity and selectivity. For some,early stationery magnetic instruments can be replaced with miniaturized RF-electric field mass analyzers good enough for satellite work. Early use for element analysis, is now extended into observation of certain organic compounds, but limited to study of structure and bonding in these compounds, since each substance put in for analysis generates a very complex "fingerprint spectrum" empirically identified with the substance, with the specific instrument and its conditions of use. A mixture of organic unknowns is almost impossible to resolve and identify at the present time, but if pre-separation and purification as by gas chromatography is applied, phenomenal sensitivities are possible.

For specific substances of interest studied: for element lines catalog (Owens-62); a variety of organics (McLafferty-63); steroids (Fitches-63). For food volatiles directly analyzed (Bazinet-60) or measured after gas chromatographic separation, see (Merritt-58, 59, 61).

For other uses: for complex ions, see (Heath-62); dissolved sea substances (Benson-61); rapid reaction studies (Goldfinger-63). Good general recent references include (Ellicott-63), (Udenfriend-62), (Masica-60), (Ewald-53).

Magnetic Resonance Spectroscopy:

Electron Spin Resonance (ESR): Some interesting possibilities for detection assert themselves here. Free radicals and reaction intermediates, paramagnetic substances such as oxygen, other substances with unpaired orbital electron spin properties can be observed to phenomenally low levels, e.g. to 10^{13} free radicals (Commoner-58), (Crouthamel-61A) with hope of extension to 10^{9} free radicals.

Amino acids, polypeptides and proteins, exhibit free radical content measurable by this technique, after their irradiation with ultraviolet (Gill-62). In other experiments of (Norins-62) a dermatologist, human skin, irradiated with 250 MU UV, shows free radical production measured by ESR apparatus (with sample in a magnetic field, and illuminated with 9500 mc. electromagnetic radiation). The work was limited to isolated material, and extended observations made by low temperature thermostatting. Both Gill and Norins' work should be extended to experiments in UV irradiation of intact skin on a man (arm, hand, etc.), at normal skin temperatures, then observing free radical production in suitably designed ESR apparatus.

Further, it would be reasonable to carry out a short theoretical study, of remote ESR observations of free radical production at skin surface, of man (at various assumed and arbitrary free radical production levels) assessing levels of excitation UV needed, and analytic illumination prospects (required magnetic and RF fields).

Other activated intermediates are observed by ESR in enzyme controlled reactions (Chance-59). Observations of such intermediates in nerve (Blois-61) have encouraged preliminary work of (Kelly-63) (at Brooklyn Polytech. Inst. for Air Force office of Scientific Research) to attempt to observe remotely by ESR (without contact electrodes on tissue) neural activity, including signal traffic. His theoretical construct revolves around assumptions derived from work of Nachmansohn, etc. an acetylcholine free-to-bound form changes associated with nerve fiber membrane alterations with signal traffic. At the time of his last available report, apparatus had not yet been completed for remote observation or experimental validations been obtained, even on isolated peripheral nerve segments. If observations of this type show significant signals due to neural activity, these should be extended to near proximity whole animal and human measurements, and tied to the theoretical analysis of far remote ESR viewing suggested above for skin.

Nuclear Magnetic Resonance: This technique revolves around nuclear (rather than orbital electron) interactions with applied magnetic and electromagnetic radiation fields.

For direct observation and data on specific substances of interest; for quantitative organic measurement, see (Williams-58), saturated and unsaturated fatty acids and protons in any materials (Jardetsky-62), phosphorus (Callis-50). For specific hydrocarbon (petroleum fraction) analyses, see (Williams-59B). For general references, see (Muller-56), on biological applications, see (Jardetsky-62).

Electrochemical Techniques.

For continuous measurement of certain substances produced by humans, various electrode probe sensors can offer high sensitivity, specificity, and good response time. For Na and K (glass)electrodes, see (Friedman-59, 61); and descriptions of good commercial instruments(illustrated by Beckman Co. data), also available from them for O_2, CO_2 and pH electrodes). For Ca electrode, see(Ishizawa-62). For other polarographic electrodes usable for various gases, see(Dehn-62). For discussions on polarographic measurement at very low concentrations of a wide variety of substances in solution, see recent editions of definitive review books by Heyrovsky, Lingane.

Anodic stripping techniques offer nanogram sensitivities for certain substances(Birks-60), for use with the trace components of Dead Sea brine, as example, see(Ariel-63).

Other electrodeposition techniques have extreme sensitivity and specificity for certain elements of interest(Weissenberger-60), down to micromicrograms in some measurements(Stolyarov-54).

Other Techniques.

Trace measurements of multiple components in biological material by radioactivity activation analysis is described by (Tobias-62), for heavier elements(Harrison-55) and in various places by (Udenfriend). Sensitivities of better than 10^{-15} gm. are attainable with adequate scintillation detectors. See (Crouthamel-61B) and other references in sections on Radioactivity in this report.

For extremely high sensitivity measurements, below 10^{-12} gm. which may be necessary for some human emitted components of interest, while no documentation is provided here, the reader should look for recent papers on nucleation techniques(eg. using halide photoemulsions, Nieset films studied by Army Chemical Corps, evaporated thin film semiconductor detectors); also the phenomenon of "fluorescence quenching".

IV. Physical Signal Sensing.

a. General Comments.

Discussion in the next few pages of specific sensing techniques and sources of information, should be related to the information in sections elsewhere on physical signal properties of man, and their environmental modification. A brief discussion follows those techniques, on systems considerations in sensing. Adequate source material is believed to be available to the reader here, to carry out system analyses of several alternate systems embodying different physical phenomena, and to construct a common model describing their behavior.

b. Radiation Sensing.

Radio and Microwave Sensing.

Heat production by man results in radiant energy emission chiefly in infrared, but also in a "tail" at low levels well into the microwave. Sensitive radiometers can observe this emission relative to surround. (See Hooper). "Calculation of target temperatures in Microwave Radiometry" Naval Ord. Lab, Corona, Cal., and microwave radiometer surveys for terrain mapping (Porter-60). For radiometers see (Copeland-61), X-band phototube (Douglas Air-63) millimeter masers (Walling-62). Other microwave (thermal radiation) measurements (Dicke-46), and general sensing biblio. (Harvest-56). For auxiliary techniques, for millimeter spectroscopy on various substances (Gallagher-62), microwave spectroscopy (Strandberg), microwave absorption measurements (Salaty-59), and "active" observations are to be considered if target is to be illuminated, see (e.g. work on coherent generation of radiation in the millimeter and submillimeter range (Hakki-61) and 100 KW 3 mm. radiation sources (Sedin-62).

Infrared Sensing.

For detector data, see (Gelinas-59), passive techniques (Barnes Eng.-59), survey of (Kennedy-60) (Levinstein-62), (Kruse-63), (Wrobel-63), for uncooled 10U detectors (Drennan-63). For recent unclassified reviews of IR-visible image converters, see (Woodhead-62) also one able to view man at 150 yards on moonless night with 45 lines/mm. resolution (Franks-62).

For supporting information on IR spectrophotometers, on accuracy (Stewart-60), 2-16U calibration substances (Plyler-60), or air borne units, see (Brumfield-60); for far IR units (Bohn-53); for filter separation up to 16U see (Billian-63). Other data, on mineral identification and measurement, see (Tuddenheim-60); IR instruments measurement, and environment problems on Atlantic missile range (Marquis-61), pulsed modulation IR systems (Wilson-60), extremely high power coherent sources, if human subjects will require illumination (Baird-62).

For basic IR references, see (Hackforth-60), (Kruse-62), review of analytic techniques (Bentley-57); military applications (Ballard-56), see also infrared Symposia (IRIS) classified reports in ASTIA.

Visible Light Sensing.

Much data are available in the current commercial literature on a wide range of photosensors (emissive, conductive, em.f. producing), image forming pickup tubes, spectrophotometers adaptable for field measurements of properties covered in this report.

If active illumination techniques are to be considered, for reflectance analysis, movement detection, behavior disturbance induction, range finding, the following open literature sources on lasers may be of value: laser range finders (Karr-63), detection of movement by Dopplermeans (Emerling-61), several physical property reviews (Birnbaum-62) (Blattner-63) and (Sirons-62) who provides a thorough systems analysis for sources, transmission medium, receiver target, etc.

Ultraviolet Sensing.

For detectors, 50-1500A review, see (Weissler-62), for good survey of "solar blind" detectors sensitive under 3000A, see Dunkelman's papers in 1963 NASA Report Series.

For supporting concepts, on UV-transmitting fluids for ultra-rapid shutters (Kerr electro-optic) see (Harris-62); interference filters (Klementyevs-60); 2000-3000A solar spectrum simulation (Norman-63), new UV laser (continuous wave, with piezo electric interference modulator) (Sylvania) perhaps usable in stimulation of free radical production in man (discussed elsewhere in this report).

For other data: military considerations on detector reflectance, scattering, calibration, see (LeBlanc-62); other middle UV applications (Green-62).

X-ray Sensing.

If unique human contrast properties are to be observed, at useful ranges with respect to air transmission, source data here may be helpful in analysis and detector selection: for image forming devices, x-ray camera tube (Rutherford-62), x-ray to visible light converter (Tunge-59). See also commercial descriptions of the range of fluoroscopic image intensifiers available.

Energy sensitive detectors, will be needed to separate sharp signals deriving from human bone Ca-P or other human characteristic return from noise background. See those used by (Porges-58) and (Gravitt-62) at ERDL.

Other Radiation Sensing Information.

For specific sensing studies for terrestrial (Drummond-61) radiometry for unenclosed object temperature (Emslie-60); photodetection parameters study (Merriam-62); spectroradiometry (Marchgrabers-59); remote sensing of environment, symposium (Institute Sci. Tech., U. Mich.). See, of course, also the annual lists of publications from Project Michigan on radiation surveillance detectors.

For good systems surveys over broad spectral ranges, of spectral suitability for communications, surveillance, (and discussion of all component measurements) for 30-10,000A see (Bayley-62) for UV to submillimeter, see (Chapman-61).

For other related data: reflectance spectrometry of opaque biological materials for chemical (composition) analysis (Shibati); from electromagnetic pulse sources and detection biblio. (Blank-63), electromagnetic hazards

(Triggering) of ordnance (Gallios-62), electro-optic and magneto-optic phenomena (Rung-59).

c. Sound and Vibration.

Airborne Sound.

In considering active illumination and sensing analysis, see "Human Attributes and Contrasts, Physical" for reflectance and other factors.

For sensing in active or passive systems (of human activity, etc.) in ultrasonic regions, see (Kamm-62), ultrasonic physics (Richardson-62), also L. Bergmann "Ultrasonics" in English translation. For measurements in various regions, see (Beranek), and related physical acoustics data (LuKasik-55), (Bolt-52) and Olsen at R. C. A. on "Acoustical Engineering".

For observation of behavioral changes induced by sound (not observable by sonic techniques), see "Stress and Induction of Behavioral Responses."

Seismic:

For passive observation, see seismic measurement data of (Bartunek-55), (U. S. A. F. Technical Applications Center and VELA-61), for seismic data processing (Phinney-62) and Soviet seismometry review (U. S. Lib. Congr. -61). In active observation, excitation of earth may be done by the explosive techniques of geophysical exploration, or, specific surface patterns induced by continuous excitation of vibration generator (aircraft "shaker" dynamic structural analyzer) and return anomalies due to human presence sought.

d. Other Physical Sensing.

Radioactivity:

See discussion under Human Physical attributes, Radioactivity, for active illumination sensing and passive sensing techniques, including those of special capability used for aircraft landing glide path aids.

For other references in this field copiously represented in the military measurement literature for sensors, see new nuclear radiation guide (U. S. A. F. Aerospace Med. Lab. -62) dosimetry field review (Taimuty-62), methods for assaying human radioactivity (Onstead-60) neutron radiography (Schultz-61) and neutron spectrometer (Friedland-62); reactor effluent analysis (Melgard-62).

Electric and Magnetic Field Sensing.

See discussion under Environmental Modifications, "Physical Signals" concerning measurement techniques.

"Non-Destructive Testing"

A variety of laboratory methods involve non-contact or remote observation and inferences about specific physical properties of materials (e. g. optical, mechanical, thermal electrical). These are chiefly extensions of techniques discussed elsewhere in this report, but can tell much about surface, internal structure, composition, loading, etc. Detailed analysis of some of these successful methods could suggest other physical and chemical attributes and properties of humans to be viewed remotely and perhaps other remote information-conveying methods. For general references, see handbook (McMaster-59), biblio (Briggs-62) surface motion measurement by proximal instrumentation (Pierce-62B). For optical methods, see (Heavens-61) and photography for surface motion (Hefferman-62). For electrostatic observation of mechanical changes (movement and acceleration, pressure), see (Brookes-Smith-39). For radiography, see (Schultz). Microwave reflectance can yield quantitative evaluation of dielectric constant and conductivity of surfaces (Hochschild-63).

By sonic methods, some in ultrasonic ranges from 0.2-100 mc/s., spectroscopic techniques and return pulse contour analysis (Gericke-60, 62) and co-workers at Watertown Arsenal look for internal discontinuities and flaws in objects "illuminated;" residual stress is measured by sonic scattering (Rollins-62), and surface hardness, ultimate strength other properties may be examined. See (Morgan-63) for ultrasonic testing techniques for diverse materials. For precise analysis many methods require that transmitter-receiver be coupled to object through liquid medium, but limited analytic measurements for materials properties can be made through an air (atmospheric) link.

e. Physical Systems Considerations.

No attempt has been made to construct a human detection analytic model in this preliminary study. Further analysis will require identification and inventory of operating parameters for each of the major components of the system. A few are illustrated below:

Human target variables to be further defined can include geometric projected area, active emission and/or scattering (and reflection) coefficients and cross sections, emissivities; their spectral, geometric (e.g. angular), time dependence; polarization, energy transformation functions (fluorescence, radioactivation, etc.); for skin and also for selected clothing, metallic and conducting objects, other companion artefacts.

Environment parameters include: background-source variables (emissions, reflections of animals, plants, terrain, atmosphere) with the same factors and dependencies for human target. Other environment signal transmission parameters describe air transfer function and spectral dependence (highlighting bandpass regions), and ground transmission for seismic, electrical, magnetic signals; variations with weather (RH, temperature), time. Transmission factors must be considered for 2 way path if active illumination of subject is used; return signal transmission may be different (due to fluorescence, radioactivation, non-linearities of air for high intensity sound, etc.).

For receiver variables, consider aggregate "black box" of sensor, amplifier, signal conditioner (calibrator, wave shape, correlator, etc.) indicator device. Variables include sensitivity, amplitude range time-based band width, radiation spectral band width, spectral resolution and spectral scan pattern, optical acceptance angle, image resolution environment scan and track variables.

If observer uses active illuminant source, variables can include: total intensity, spectral distribution, degree of coherence, modulation wave form, beam angular dispersion, ratio of target to background illumination.

System variables to be derived include contrast ratios (selected human signal variables versus corresponding environment background level); energy product-integral (integrated for selected bandpass regions) taking into account (source spectral emission, target and background spectral emission and reflection, air, etc. spectral transmission receiver spectral sensitivity). Of interest are total sensitivity, working range, human contrast ratios for positive identification, angular resolution.

These are all but a preliminary and primitive point of departure for construction of a theoretical model for predicting the comparable effectiveness of various physical phenomena in human detection, and could be made broad enough to permit study of chemical variables and chemical detection systems. Military and civilian surveillance system analysts have a great number of satisfactory systems models for such analyses; they await only good information on new aspects of human emissions and contrasts.

F. OTHER RELATED INFORMATION

I. Stress and induction of Behavioral Response

In concealed enemy "illumination" by physical, chemical, biological or psychological means, may induce additional behavioral and neural responses useful for detection. Such responses may be obligatory, unavoidable, physiological, or related to the induction in enemy mind of real or fancied threat to mission and life.

Return signals from such behavioral and neural response may take the form of various direct emissions (ex: EEG changes), body movement and activity responses, or indirectly contribute by placing the enemy into a more exposed position for detection, or by alteration of his course of action, or temporary or permanent neutralization of rational behavior, remove him as a threat.

In brief form we consider specific stresses and performance changes, light, sound, movement restriction, sleep deprivation, CW alteration, other physical and chemical stimuli having psychological impact. Many initial physiological degradations discussed are but way-stops towards reduced psychological performance capability.

Light Stress. . Flickering light was investigated by many as a means for degradation induction; for broad coverage of human responses, see the ERDL Flicker Symposium(Bach-57). For detail on various central nervous effects, see (Walter -49) more recently (Brazier-2 refs) including EEG changes and generation of illusion and hallucination. For other mechanisms, topographic mapping of regional brain responses see (Ulett-58). Repetitive light, also called "photic" stimulation, is used diagnostically at low light pulse repetition rates(under 15/sec) to evoke seizure activity or EEG changes in latent epileptics or those with CNS lesions. EEG response events in normals have a certain synchrony with the repetitive light stimulus, and if human neural activity could become observable by non-contact methods, remotely(discussed elsewhere in this report), a photo-stimulation-synchronous detection system might be considered for man.

In normal people at low repetition rate of pulsed light stimulation sensation is of separate light pulses up to a point of continuous light sensation (CFF at critical flicker fusion frequency). For extensive data on this, see bibliography of (Landis-53), studies of (Bartley- 37, 39, 51) prolonged stimulation effects (Alexander-59); alteration of CFF with simultaneous patterned sound stimulation (Kravkov-35A, 35B) (Knox-45A, B) (Maier-61) (Ogilvie-56). If paired flickering sources operating at different frequencies are used simultaneously, an additional sensation of visual beats (at difference frequency) is produced. (Attneave-50). These various effects described by authors above can be produced even when eyelids are closed, if source is bright enough, and for certain desired effects(behavioral alteration, neural signal return) repetitive pulsed laser beams may be considered for this purpose, with exploration yet needed of effects of stimulus pattern and waveform, other than simple repeated pulses.

Personal protectors, goggles, mask, countering this would have to be applied in advance, would obscure the use of vision for other tasks at the time, and would be an extra equipment burden not likely to be carried by enemy forces, except under total threat conditions.

Direct electrical stimulation of the head and of the eye can induce visual sensation (Bogoslowsky-37,47A,47B) (Bowman-35-51). No documentation has been seen of such induction by remote electromagnetic radiative or electric field action.

Another light stress involves use of a bright unexpected flash source, producing temporary incapacitation, perhaps during important viewing periods, or persisting to destroy night vision or permanent blindness.

Related Visual Capabilities Information:

Degradation must be consideredin relation to standards of performance, for a given operational task. The following will provide useful sources on operational needs for vision in reconnaissance, search and detection recognition. For detectability in visual search , target factors, see (Kulp-59); and contrast as a function of illuminant spectrum, see (Nagel-56); for dark adaptation responses bibliography (Crook-53); for continuous search problems, (Delse-53) (Ericksen-54). For form discrimination (Fox-57) and its determinants (Bitterman-53) for other pattern recognition concepts see (Weisz-58), and in relation to target geometry (Steedman-60). For other visual capability in the action enviroment , see (Blackwell-57A,57B), and in special problems of military aviation (Wulfeck-58). Visual presentation of information (Baker-54) and visual interpretation of photographs and fixed electronic images, see (Waldron-61) (Gwier-56) (Shenkle-56).

Sound and Noise Stress

Noise is observed to have many effects on human behavior. (Corso-50-52), (Anthony-57)(Azrin-58), for animals (Ades-53)(Ackerman-53). (Hale-53); for biological changes. Sensory changes include altered visual performance (Broadbent-54) (Loeb-54); including altered visual signal detection (Watkins-63). Noise also can produce body movement changes (Krauskopf-55), and muscle tremor (Loeb-54).

Intermittent noise has special effects, somewhat similar to flickering light. At low interruption rates it is perceived as separate pulses (flutter), fusing into continuous sound sensation at higher rates (Allen-24) (Ogilvie-56) (Gebhard-59). Interrupted sound degrades a variety of mental capabilities (Ogilvie-56) (Gebhard-59), also inducing confusion, inattention (Mowbray-56). For other CNS effects see (Smith-50), and for EEG responses and changes, see (Mimura-62).

Speech communication (production and reception) can be systematically altered. For speech jamming, see bibliography (Moyer-55),(Christman-57B) (Licklider-57), and (Stewart-58). Stewart also discusses antijamming procedures.

Sound and noise sensation, and disturbances due to them, can be induced in man with RF energy directly beamed at the head. See (Frey- 61A,61B,62), using fairly low energies, a variety of frequencies and modulation patterns. (This might be classified as Radiation Stress, RF Reception, etc).

High intensity audio or ultrasonic airborne sound has distinctive effects on living material, close to the sound source, unfortunately not observable afar (more than a few feet) because of the limited properties of air to conduct this energy (non linearities at higher amplitudes).

High intensity vibration. Special effects on man, surveyed by (Edwards-50) (Coermann-60) (Goldman-52, 61).

Related Hearing Capability Information

For normal performance capability data, for noise detection, see (Green-60A) sound localization (Snow-54) (United Research-62); accuracy in gun fire localization (U.S. Army ORO-58); and localization capability with conflicting hearing and visual cues (Witkin-52). For hearing vs. vision, for communications see (Cheatham-50), (Day-50), (Henneman-54).

Other Stressors

For temperature effects, for low temperature, see (Carlson-54)(Rodahl-57A) human temperature limits, (Wing-63), (Fenning-54). Heat regulatory responses (Newburgh-59).

For sleep deprivation effects (100 hrs.), see (Edwards-41), psychological changes (Murray-58), other impaired performance (Williams -59). For work-rest schedule change effects (Ray-60), (Chiles-61). For altered daily patterns and performance effects (Brindley-54).

For restriction of movement and confinement, effects on exploratory behavior (Montgomery-53), perceptual function changes, see (Ormiston-61), and responses of captives (Biderman-61A, 61B). For sensory deprivation and behavior see (Wheaton-59), (Leiderman-61) and effect in visual processes (Heron-56) for sensory isolation and confinement biblio. see (Weybrew-60).

Many drug agents offer possibilities of incapacitating potential (see any good recent pharmacology compendium such as Goodman and Gilman). With these and newer psychopharmacological materials (see "Psychopharmacology" published by U.S. National Research Council) there are manifold possibilities for promoting detection by physiological alteration and CNS sharp edged "chemical dissection" for behavior distortion, not to be catalogued here. Documentation of specific potential agents, and supporting techniques and possible modes of use having tactical worth related to the detection problem are kinds of information best sought from such sources as the restricted accessions lists and card catalog of holdings of the Army Chemical Laboratory at Edgewood, Md., Army Biological Laboratory at Detrick Md., etc.

For other drugs affecting performance see one biblio. (Trumbull-58).

For thirst data see (Wolf-58).

Microwave Stressor Effects: Functional disablement and death without pathology is reported, for Rhesus monkeys, by Dr. P. Bailey of NIH = National Institute for Neurological Diseases and Blindness; with similar results reported, using 300 mc. carrier, 500-1000 cycle sine modulation (see Bach, p. 82 U. S. A. F. 3rd Annual Triservice Conf. on Microwave Hazards). For sleep induction by pulsed RF see (Burhan-59). Visual system damage includes lens opacity and tissue degeneration, for 3 cm. data, see (Buchanan-61) (Susskind-51); at 10 cm. (Carpenter 59, 62). For other CNS degradations see conditioned response experiments of (Jaski-61) . For induction of hearing sensation see (Frey-61A, B, 62). For skin damage see (Novaro-50). For other hazards see reviews (Turner-62)(Schwan-56A, 59) (Hines-52) (Jaski-61); for pathological and physiological changes (Herrick); for effects on isolated tissues (Schwan-57B) and on specific organs (Myrtenko-62A) other local effects (Myrtenko-62B).

Responses to Applied Electric Fields: Electric signals can induce visual sensation (with electrodes applied to head). Fairly low power is involved see (Schwarz-38) for quantitative data re stimulus quality, adaptation (Schwarz-40A, 40B, 47) (Motokawa-49, 50A), certain resonance effects (Motokawa-50B), selective color stimulation (Motokawa-52), . For the specific eye and CNS structure responsible for electrosensitivity, see (Brindley-55) and for sensation induced in dioptrically blind (retina intact but cornea, lens opaque) see (Barnard-47).

Electrostimulation techniques for hearing are being investigated by (Intelectron-63). Electrical sensitivities of skin presently are only exploited in communications studies with all variables of voltage, current, waveforms and spatial patterns available from this. See (Anderson-51), (Hawkes-59A, 59B), (Foulke-62). No direct attempts have been made to use remote electrical methods for inducing some of the bizarre sensations or hallucinatory responses relative to the common special senses described above. Direct or remote electrostimulation as a stressor has the potential of inducing a variety of degradation responses. (See wide range of papers and monographs on Electro Shock in the psychiatric literature). But some of the effects set down are interesting enough to explore the parameters and mechanisms for remote induction of behavioral response by electrical means.

Other Comments on Psychological Stressors: A good starting point for review of disabling techniques can consider the inverse of those factors found to promote survival and stable behavior in disaster situations, as those below, modified from (Smith and Cox-57) studying reduction of human stress after irradiation, and (Torrance-53) on survival psychology: many specific physical or chemical stressors can be used to induce one or more of these actions: impose new situationes , unfamiliar to enemy , and designed to make certain of his training worthless; keep him as ignorant of his true situation inducing his disorientation if possible; (see Withey-56 - reaction to uncertain threat). Induce fear, panic, anxiety, insecurity as to his future situation. For source references: on anxiety, initiation , its communication and interpersonal management (Ruesch-49), anxiety induction and intellectual function (Beier-51); fear-arousing communications (Janis-53), anxiety and hysteria dynamics (Eysenk-57); deception detection (Ellson); seek to reduce his belief in his own effectiveness and his resolve and determination, induce personal conflict, reduce confidence in his leadership; seek to modify his action, either immobilizing him, or forcing hasty action.

Magnetic Field Stressor Actions: No definitive data on human degradations in exposure to strong magnetic fields was seen in the literature although preliminary explorations by (Beischer 62A,B) in such exposures have begun.

For induced visual sensation see (Swinton-11)for quantitative analysis strength-duration data, typically at 900 gauss, 60 cycles (Barlow-47).

For other speculations on human responses to magnetic field stresses see (Hansen-48A), who postulates the autonomic nervous system as the mediator of such effects (Hansen-49), other vague physiological effects statements (Thompson-10) (Fleishman-22).

Other Behavioral Responses to Stress: Vigilance can be defined as attention to a task involving important infrequent events. (e.g. for anti-submarine warfare biblio.-see McGrath-61A). For vigilance reduction, see (Frazer-52) (Wade-61) and for general neglect of attention to changes in surroundings, see (Berlyne-51).

For fatigue sensation and performance impairment, behavioral and physiological changes, see biblio. (Bevan-57) for measurement (Motakawa-48) and induction, see (Bowan-52), for skilled performance degradation, see (Bartlett-41), and biblio. (U.S. Joint Service Steering Committee for Human Eng'g..), for other effects, see (Univ. of Md. Psychol. Dept-52),

Various odd behavioral responses, biblios. of military psychiatry (Roos-59, 63); ecology of psychiatry (Meerloo-59).

Other Changes in Response to Stress: For general reviews see(Grinker -45) (Lazarus-52) (Harris-56) symposia (Tyhurst-50) and others (Klier-60) (Renbourn-61), biblio. (USASTIA-Bib.-62) (U.S. Army Med. Service Grad. School-53) physiological and behavioral measures (Notterman-55), biblio. on development of stress-sensitive tests (Iller-53) decrement in aircraft stress (Finan-49)c basic performance capacity study (Spector-61), desert survival responses (Howard-53).

Heart rate in anxiety (Dean -58) and CV changes related to religious practice (King-57); conditioned heart rate response, control (Bersh-57).

Skin secretory changes under emotional stress have been classically studied (C.Darrow-34) also by (Conklin-51)(Johnson-59) by measurements of skin resistance and other electrical changes (e.g. GSR or galvanic skin response). Such changes will affect the pattern of released chemical substances, also in changes of surface conductivity, skin blood distribution etc. may be observable as electromagnetic radiation emission or reflection changes.

II Some Other Human Spotting or Remote Data Transmission Problems

Casualty Location:

Even when individuals are equipped with small beacon transmitters, and are deployed around the terrain in stationary semi-concealed positions, simulating casualties, it is difficult to find them: (See records of survival location experiments conducted by Stanford Research Institute at Army Combat Development Experiment Center in Calif., with average locating time 1/2 hour (U.S.-CDEC-61). Urgent desire of Army Surgeon General's Office to locate personnel (casualties) quickly because of hemorrhage etc. despite difficulties of security, enemy decoys, radio propagation, has promoted studies chiefly of manually and autotriggered active emitters (radios) carried by all, (eg. 265 mc., a few milliwatts, 500 yard range). While we cannot hope to put active emitters on enemy ("bell the cat"), broader surveys of various active and passive information links for casualty location have been undertaken; this information and the experimental procedures used in deploying concealed casualties under realistic tactical conditiones, can be of value in conducting concealed personnel detection experiments or studying alternate locating techniques. See also (Jackson-62) and from Air Force Study on survivor locating devices, see (Matrix Corp-61).

Physiological Performance Telemetering:

To assess human biological and psychological changes at tasks in remote or enclosed environments (aircraft, satellite, undersea, land vehicle, chamber), varieties of transducers applied to the body measure biopotentials (EKG, EEG, ERG), blood pressure, respiration, temperature newer variables; electrical signals produced modulated RF or inductive transmitters mounted on the person or wired within the environment, and remote decoding of signal is done in "real time." Only little encouragement is available for remote sensing of any of these variables, of characteristic patterns denoting human life without the transduction of each variable into a modulated RF signal. Exception would be skin temperature (and associated IR emission), perhaps other passive (reflectance and scattering) responses to electromagnetic radiation, particles cited elsewhere in this report. But the basic internal human signals, (e.g. of EKG, respiration, heat production) exist in roughly invariant pattern as long as life persists in the man and represent an interesting but presently elusive "handle" to get at for remote detection.

Animal Tracking:

Similar data on physiological conditions, and on movements are collected in recent animal studies; for radios on grizzly bears, see (Craighead) other wild animals (Lord), woodchucks (Merriam). There are similar studies on birds especially related to navigation, for fish homing (Hasler and Henderson), on monitoring of locomotor and electrophysiologcal activity, see (Dutky and Schechter of Dept. of Agriculture). In future human detection experiments, transmitters placed on some of the large members of the animal population in the selected area, will provide location correlates for other physical and chemical interferences with the human location principle under study.

III. BW-CW Detection Problem Similarities.

Aid in analysis and solution of the human detection problem can certainly be derived from the past and present efforts on BW and CW detection with which many points of correspondence exist. Air sampling, collection and concentrating its contents into a convenient volume for chemical, physical or biological analytic instrument, must take into account the same kinds of micrometeorological (e. g. temperature and movement gradients, turbulence) mechanical (devices) statistical (space and time sampling) and chemical problems, whether for remote observation of human chemical product, or trace amount of chemical toxic or biological pathogen. Additional similarities exist in distinguishing the agent (or human product) from background substances from animals, plants, industrial wastes, etc., and in the selection of specific and known compounds in the tissue or products of microorganisms unique to those organisms (e. g. amino sugars, D-amino acids, diamino pi melic acid, etc.) (see Wolochow-59).

For good speculative early surveys of a wide variety of techniques for BW detection, see (Bateman-51) and more definitive reviews of many possible physical and chemical principles for BW detection by a National Research Council Advisory Committee, see (Bolduan).

For a few examples of some common instrumental approaches, see partichrome viable-particle stain and size distribution analyses (Nyman-62); protein analysis in air, at 10^{-9} g/l (Buban-62); determination of microorganism IR spectra (O'Connor-Dept. of Agriculture-55); determination in atmospheric paths of IR absorption by certain CW agents (LOPAIR technique); for a variety of early protein and bacterial methods (fluorescence, serologic, dyes, see (Armour Research Foundation-54); for more recent biochemical detection methods, using bacterial enzymes and fluorescent techniques. See (Mitz-62) and for exploration of chemical concentration profile procedures, see (Melpar-61). For general review of use of living materials as transducers for BW detection, see (Kornfield-62A, B, C, 63).

To get current information, consult the work in progress on new techniques by two major BW Detection System Study Contractors (Melpar-Falls Church, and Aerojet General, in California), in behalf of Ft. Detrick, Physical Defense Division; the corresponding CW Detection efforts monitored at the Army Chemical Laboratory and CBR Agency at Edgewood, the reports disseminated through DDC (formerly ASTIA) "Field of Interest Sections 3 and 3A", and the Technical Document Library resources at Army Chemical Lab and Army Biological Lab.

IV. Other Useful Information Sources.

In the course of our review, the following sources were examined, and may be useful to a reader going further in study of areas described in the report. These are not cited elsewhere in the report.

Biology: For distribution and abundance of animals, and ecology, see (Andrewartha-54), (Clarke-54), (Clements-39) (Kendeigh-61) (Alee-49) (Odum-59), including a glossary (Carpenter-56) and animal geography (Hesse-51), (Darlington-57) (Hubbs-58) (U.S.A.F. Arctic Aeromedical Lab Publications-1962). For wild animal studies under controlled conditions see (Calhoun-56), for animal attractions and repulsions (Coleridge-20), animal orientation (Fraenkel-40); for ecology of parasites, see (Baer-51) and for host specificity (Becker-35). For insect physiology, see (Wigglesworth-53), on bumblebees (Free-59), yellow fever mosquito (Christopher-60), and other mosquitoes (Bates-49), spiders (Bristowe-58), ticks (Arthur-62), and insect control biblio (Horrigan-51). For mammals, see field guide (Burt-47), also (Anthony-28) (Hamilton-59), mammal bioclimatology (Pruitt-56), and tropical and arctic mammal and bird heat (Scholander-50). For falcons studies as pets and hunting animals, see (Russell-40) (Momin-45) (Wood-55).

Chemical Analysis: For amino acid separation, see (Hamilton-59); for amino acid automatic analysis (Piez-60); and for amino acid handbook (Block-56). For ammonia determination, see (Connerty-57) (Henry-58) and for on detection and differentiation of glucose and amines, see (Williamson-63). For lipid biochemistry see (Devel-55), and for all the properties of water in early work, see (Dorsey-40). For general biochemical reference, see (Merck Index-60), normal clinical lab data (Mattice), big compendium on methods (Gradwohl), other standard methods (Welcher-63), industrial toxicological chemistry (Elkins-59), drug detoxication mechanisms (Williams-59A); for insect biochemistry, see (Gilmour-60).

Perfume Chemistry: related to identification by scent producing animals, chemical composition of scents, chemoreceptors and biosensing (discussed elsewhere). General references (Askinson-24) (Hoffman-48) (Pounder) (Jellinek-54) good work of (Givaudan-49); (Moncrieff-49); (Verrill-40), others on animal perfumes (Sagarin-44), (Lederer-46), musk odorant composition (Pogert-20) (Ruzieka-26), natural and synthetic musks (Dyson-31); mercaptans in cosmetics (McDonough-47); also on cosmetic materials (Keither-56) (Sagarin-57), handbooks (Greenberg-54) (Denavarre-57); and for flavors and essences (Gazan-36).

Physiology and Psychology: For some useful items consulted, see neurophysiology handbook (Magoun-60); cardiorespiratory functions, handbooks (Altman-58, 59); (Dittmer-58) (Gordon-60); gastro intestinal function (Alvarez). For environmental physiology (Glascick-60). For Physiological and Biological Data for Bioastronautics Handbook, see (U.S.A.F. School of Aerospace Medicine, Brooks A.F.B., Texas, and 19 year cumulative biblio. of research reports issued by Naval School of Aviation (aerospace) Medicine (Daniel-61).

Other Scientific References: See periodic publications as biblios. of following: for electronics (U.S. Army Electronics R & D Lab, Ft. Monmouth), Radiation Effects Info. Center (Battelle-63) 1962 OakRidge National Lab (Johnson-62); (U.S.A.F. European Office of Aerospace Research-62) and basic Research resumès from U.S.A.F. O.A.R. (U.S.A.F. Res. Div.-59), U.S.A.F. Flight Test Center 10 year publications list (Lemmon-63). See also Proc. 5th Ann.

Naval Science Symposium (U. S. O. N. R.): biblios from Aero Establishment (Nat'l Res. Council of Canada-62); translation lists of (Royal Aircraft Establishment, UK-61), science and technol. reports from (Indian Council for Science and Industrial Research).

Selected Military Information Sources: For Limited War problems review by DoD task group, see (U. S. DoD. Director of Defense Research and Eng'g-61A). For limited war biblio (Halperin-61).

For Guerilla Warfare, see (U. S. C. I. A. -50, 62) (Virgil-60, 61), Fort Sill biblio (Hollowar-62), Marines biblio (Johnstone-61), Air Force biblio (U. S. A. F. Acad. Lib. -61) and (U.S. Army Field Manual F. M. 31-21). For others on counter-insurgency, biblio (Vigneras-62), Marine biblio (U. S. M. C. -62) (Condit-63), DoD. biblio. (U. S. J. C. S. Spcl. Ass't for Ctr.-Insurg. -62); training biblio (Osanka-62A) (Hosmer-63). Others on special warfare, biblio (U. S. Army Spcl. Warfare School-62) and Fort Sill Biblio (Holloway-61), operation against irregular forces (F. M. 31-15), Ranger training (F. M. 21-50), evasion and survival (Green-57), theory of search for conscious evader (Norris-62).

For other sources; jungle operations (F. M. 31-30); mountain operations (F. M. 31-72); psychological operations biblio (U. S. Army Spec. Opers. Res. Ofce. -60). Unconventional war concepts (Condit-56) and biblio (Miller-61). For counter-guerilla action by air, see (Osanka-62B), and for visual target acquisition from armored helicopter (Thomas-62). For military small group performance in isolation and stress, see (Sells-61), factors relating to successful and unsuccessful unit action (McKay-59), and for military leadership biblio. (Ruch-53).

For related Asian regional data, see Asian Guerilla movements (Hanrahan-53) and biblio. from (Army) operations Research Office (U. S. O. R. O. -54), anti-guerilla action in S. E. Asia (U. S. Navy-62). For earlier military actions in three Asian theaters, see (Barchan-O. R. O. -53), S. E. Asia (Human Relations Area Files, at Yale). For Laos communist strategy, see (Halperin-RAND) and Indonesian communist tactics (Parker-RAND-60); for S. E. Asia Combat Team Studies, see (Clark-58).

G. SUGGESTED FURTHER WORK

A useful extension of this survey, its sources and findings, can include the areas of study highlighted below. We have starred(*) those which appear most promising. These specific recommendations made do not rule out the further analysis in depth of all of the major areas touched on, and the continuing contact with the literature and active workers in each field. That further broad scale analysis is the major way to obtain all of the information needed to complete a proper comparative evaluation of the possibilities presented.

Recommendations include review efforts, analyses, or experiments, either in support of a primary concept(sebum analysis data), or in test of the primary concept itself(EG. controlled experiments on biosensing of sebum, or of dog tracking of sebum trails). The work suggested here may be intended to make up for data deficiencies in the literature, or to present a positive outlook towards the testing of a good prospective detection concept. Where experiments are suggested, it is assumed that they will not take an inordinate amount of experimenter time and skill, that apparatus can be assembled or designed fairly easily.

On Human Attributes:

1. Assemble a collection of foreign medical teaching texts, hospital manuals, lab data books, published locally in principal geographic regions of interest, and containing indigenous "normal value"data, on urine, feces, sweat. These would be books in biochemistry, clinical lab analysis, pathological physiology, etc.

2. Carry out gas chromatographic analytic separation of whole sebum from skin of various ethnic groups, fresh and after bacterial decomposition; for use in identifying sebum components, maintaining a sebum "fingerprint" library, and making available sebum materials for sensing experiments and tracking studies.

3. Conduct simple experiments on the remote observation of disturbance by man of natural magnetic and electric field patterns, as indicated within report.

*4. Conduct experiment on the observation by ESR(Electron Spin Resonance) techniques of the free radicals which may be produced by intact human skin, after excitation with UV radiation, in suitably designed equipment, and after the manner of the successful isolated skin experiments herein.

5. Make simple spectral reflectance measurements on skin of a much broader variety of ethnic groups of interest, than now found in the literature (as sampled in this report), using wide-band (Middle-UV to middle-IR) spectrophotometer, compact recording type of commercial design.

6. Assemble data on spectral reflectance, UV through IR of current clothing and special forces combat equipment, or representative samples of enemy equipment(where such measurements are not available from QMRE, ERDL, Naval Materials Lab, supplement with measurements made as in 5 above.

7. Assemble tables of "normal values", urine, feces, sweat, from the special information sources set down in 1.

8. Carry out comparative analyses of the "normal values"data from 7 above, and "North Atlantic Normal" data as found in sources contributing to the table in this report; to unearth significant differences in specific fractions, or in concentration profiles.

9. Assemble data on human reflectance and scattering of x-rays, over a wide energy band, as available from diagnostic and therapeutic radiology and health physics reference sources.

10. Review suitable literature to establish validity of hypothesis that human tissue trace mineral composition is a function of soil mineral content in the region where the human spent his years to maturity.

Environmental Background

* 11. Assemble data on plant contributions to the chemical background in air, from measurements of Dugway Proving Ground, other sources cited within report.

12. Arrange to receive airborne material chemical and biological samples, from regional environments of interest, either through any systematic collection and surveillance measurements made by CBR Agency, PHS, or Army Surgeon General; etc; or by providing collection equipment as extra job for assigned special forces personnel.

13. Carry out comparison of human product components and concentrations, with those from animal and plant sources (listed in report) and with plant and general environment substances in 11 and 12 above; to unearth human products which are entirely unique or have high concentration ratios (human products/other products).

Sensing

*14. Conduct simple experimental series, with isolated tissue materials set up as biosensors, and exposed to selected human products. Series can include: frog skin and electrical measurement; guinea pig intestine, heart, aorta strip with mechanical contraction measurement; exposure to whole sebum or its fractions, etc. See description in report of these biosensors.

*15. Carry out simple similar experiments using selected chemoreceptor isolated preparations, arranged for electrical measurement; using for example: antenna of silkworm moth, parts of blowfly, etc. Stimuli can be as in 14 above.

*16. Carry out experiments in attempy to sensitize guinea pigs to human sebum and some of its fractions (from individuals and pooled sebum). If serological methods show this to be successful, prepare isolated intestine strips from some of these sensitized animals, for experiments as in 14 above, but seeking enhanced response to sebum.

17. Carry out comparative analysis to match up list of known human excreted products, with their counterparts in proven specific chemosensitivities of good chemoreceptor preparations, to obtain more suitable preparations for experiments as in 15 above.

*18. Carry out short analysis of the several possibilities for ESR (Electron Spin Resonance) observation by remote means. Maintain surveillance over the work cited in report being attempted on non-contact ESR studies for signals from nerve.

19. Carry out analysis of possibilities for detection of characteristic X-ray signal return from humans, in conjunction with search for very high intensity developmental X-ray sources (perhaps x-ray lasers).

*20. Prepare a good theoretical systems model, using the concepts outlined in the report, which would be useful in common for systems detecting either physical or chemical attributes, and employing physical, chemical, or biological sensing; and test out this model for predictive capability for sensitivities needed of detectors for various effects, etc.

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