

contents

Foreword 28
Preface 30
Areas of circles 32

SECTION

I

Pulp and paper science

1.

The bonding of matter 34

Electrical charges	34
Atomic structure	35
Reactivity	36
Chemical bonds	36
Bonds in water	38
Valency	39
Units of measurement	40
Bondstructure	41
Carbon-carbon bonds	42
Carbon-hydrogen bonds	42
Carbon-oxygen bonds	43
Miscellaneous bonds	44
Bondenergies	45
Hydrogenbonds	45
Van der Waals forces	47
Liquefaction	47
Crystal formation	48
Mechanical binding	48
Frictional binding	49
Reformed bonds	50

Hydrates and bound water	50
Summary	52
References	53

2.

Some properties of fluids 54

Water	54
Structure of water and ice	54
Viscosity of liquids	56
Viscosity of water	56
Specific heat	57
Latent heat	57
Solubility	58
Surface tension	58
Pressure and surface tension	59
Effect of additives on surface tension	60
Surface and liquid tension	62
Solution concentration	63
Hydrogen ion concentration (pH)	64
pH of water and solutions	64
Vapors and gases	65
Absolute and relative humidity	66
Measuring relative humidity	66
Humidity and moisture absorption	66
Summary	67
References	68

3.

Some effects of forces 69

Units of force	69
Stress and strain	70
Youngs modulus	71
Units of energy, heat, and power	71
Moment of inertia	72
Deflection of beams or rods	73
Modulus of rupture (MOR)	73
Shearing by deflection	74
Kinetic principles	75
Newton's laws of motion	76
The inclined plane	76
The pendulum	77
The pendulum wheel	79
Centrifugal force	79

Circular measure	80
Hydrostatic forces	81
Density of small objects	81
Fluids in motion	82
Flow through pipes	83
Flow through orifices	83
Viscosity	84
Summary	85
References	86

4.

Surface phenomena 87

Colloids	87
Definitions	88
Sedimentation	88
Particle charges	89
Some effects of charges	89
Electrical double layer	90
Electrokinetics	91
Electrophoretic mobility	91
Hydrated colloids	92
Coagulation and dispersion	92
Flocculation of hydrophilic colloids	93
Sorption	94
Adsorption of water by cellulose	94
Sorption of water and swelling of fibers	95
Boundwater	%
Moisture in pulp and paper	97
Area of surfaces	98
Surface discontinuities	99
Heat of adsorption	99
Adsorption of additives	99
Surface films	100
Miscellaneous adsorption phenomena	101
Wetting, spreading, and penetration	102
Syneresis	103
Summary	104
References	105

5.

Carbohydrates. cellulose. and lignin 106

Carbohydrates	106
Identity of celluloses	106

Structure of glucose	107
The structure of cellulose	110
Hexosans and pentosans	111
Uronic acid groups	112
Constitution of fibers	113
Hydrolysis of cellulose	114
Sugar and alcohol from wood	114
Degree of polymerization	115
Viscosity and DP relationships	115
Chain lengths	116
Hemicelluloses	116
Hygroscopicity of cellulose	117
Effect of substituents on hygroscopicity	117
Moisture in beaten cellulose	118
Lignin	119
Influence of lignin on pulp	122
Summary	122
References	124

6.

Structure of wood and other fibers 125

Wood density	125
Chemical composition of wood	126
Softwood and hardwood fibers	126
Mechanical defects in fibers	129
Middle lamella	130
Interior structure of fibers	131
Inner secondary wall	132
Fibrillar angles	132
Tertiary wall	134
Ultrastructure of fibers	134
Laminae in fibers	134
Pores in wood fibers	135
Cotton fibers	136
Linen and other fibers	137
Utilization of fibrous plants	138
Fiber composition of paper	138
Splitting of fibers	138
Cellulose chains	139
Crystallization in fibers	140
Recrystallization	141
Strains in dry fibers	141
Summary	142
References	143

7.

Bonding of cellulose surfaces 145

Bonding by adhesion	145
Bonding by cohesion	146
Function of paper bonds	148
Shearing of joints	149
Wet compactability and bonded area	150
Fiber cross sections and deformation	150
Molecular fibrillation and partial solubility	151
Bonding smooth cellulose surfaces	152
Bonding viscose fibers	153
Chemical bonding	155
Corona discharge effects	155
Hemicelluloses on and in fibers	156
Hemicellulose and swelling	156
The influence of lignin	157
Summary	157
References	159

8.

Fibrillation and fiber bonding 160

Internal and external fibrillation	160
Fiber softening	160
Fiber surfaces	161
Dried fiber surfaces	162
Visibility of fibrils	163
Scanning electron microscope evidence	165
Effects of mild mechanical treatment	167
Rapidity of change with beating	168
Strength of fiberjoints	169
The need for fibrils	169
The need for liquid water	170
Conjunction of moist webs	170
Compaction of moist sheets	172
Effect of hemicellulose on bonding	172
Clotting of lightly beaten pulp	173
Bonding of high-yieldpulp	173
Bonding of alpha-cellulose pulp	174
Effect of additives	175
Effect of electrolytes	175
Alkylated pulp bonds	176
Rebondedsheets	176
Bonding of air-felted sheets	177

The importance of fibrils	177
The importance of molecular fibrils	178
Summary	178
References	179

9.

Properties of pulps 181

Modifications of pulp properties	181
Suitability of pulps	181
Chemical anomalies	182
Hypothetical relationships	183
Pulp and stock qualities	183
Principal pulp properties	183
Relationship of pulp properties	186
Miscellaneous pulp properties	186
Evaluation of northern and southern kraft	187
Shortcomings of conventional data	188
Advantages of more fundamental data	188
Characteristics of various pulps	189
Differences in wood pulps	190
Mechanical pulp	191
Thermomechanical pulp	191
Semichemical pulp	193
Full chemical pulps	194
Sulfite and sulfate pulp characteristics	194
Effects of bleaching	195
Effect of drying	196
Application of the fundamental tests	196
Routine pulp evaluation	197
Summary	198
References	200

10.

The making of paper 201

Early papermaking	201
The demand for pulp	201
Groundwood pulp	203
Soda pulp	204
Sulfate pulp	205
Sulfite pulp	205
Pulp preparation terms	205
Beating	205
Early stock preparation	206
The hollander	208
Beater development	209

Conical refiners	212
Disk refiners	214
Passage to the paper machine	216
The paper machine	216
Forming the paper web	218
Pressing and drying	219
Machine additives and finishing	220
Stock drainage	220
Wet-web strength	221
Draws	221
Two-sidedness	222
Twin-wire machines	222
Cylinder machines	225
Machine influences on paper properties	226
Summary	226

SECTION

II

Pulp treatment and tests

11.

Moisture content of pulp 230

Weight of pulp shipments	230
Distribution of moisture in bales	230
Moisture distribution studies	231
Sampling by boring disks	231
Sampling errors	237
Wedge method of sampling	238
Modified wedge method	239
Angle of wedges	241
Bale wrappers	241
Number of bales sampled	241
Randomizing of bales for sampling	242
Methods for lapped and shredded pulps	243
Modified disk-boring method	243
Wedge vs disk sampling	243
An unusual method	243
Cutting pulp samples	244
Moisture in pulp samples	245
Effect of temperature on drying	245
Bound water	245
Drying shipment samples	246
Electric ovens	247
Steam oven	247
Special methods for moisture and weight	248

The importance of pulp sampling	249
Concentration (consistency) determinations	250
Abstracting exact quantities of stock	251
Weighing out desired quantities of moist pulp	251
Routine consistency measurements	251
Continuous measurement of low concentrations	252
Consistency pencil	254
Consistency measurement by pressing	254
Summary	254
References	255

12.

Nature and effects of beating 257

The importance of beating	257
Strength and other characteristics	258
Need for beating	258
Practice of beating	258
Main effects of beating	258
Secondary effects of beating	260
Miscellaneous results of beating	260
Indirect effects	261
Bar-fiber actions	261
Fiber changes	262
Shortening	263
Effects of shortening	263
External fibrillation	264
Effect of size of fibrils on bonding	265
Fibrils on dried and never dried fibers	266
Internal fibrillation	266
Effects of hemicellulose	267
Apparent swelling	267
True swelling of unbeaten fibers	268
Swelling of beaten fibers	268
Swelling of smooth fibers	269
Swelling of fibrillated fibers	269
Objections to the role of swelling	270
Behavior of viscose fibers	270
Production of debris	271
Effects of debris	271
Compression and curling	272
Effects of compression and curling	273
Heterogeneity of action	273
Homogeneous vs mill beating	276
Questionable concepts of beating	277
Hydration, shortening, and freeness	277
Summary	278
References	280

13.

Mill beating and refining 281

Beating variables	281
Selection of equipment	281
Beaters	282
Beater operation	284
Efficiency of beating machines	284
Conical refiners	285
Bars in conical refiners	285
Clafflins	286
Disk refiners	286
Advantages of disk refiners	288
Miscellaneous mill beating equipment	290
Choice of beating equipment	291
Action of beating equipment	291
The purpose of beating	294
Invalid measures of beating	294
Fibrages on bars	294
Clots on bars	295
Appearance of the bars and fibers	295
Stock consistency and bar action	2%
Imbibed water	297
Fiber compression	297
Consistency and circulation	298
General influence of fiber structure	298
Influence of fiber wall thickness	298
Influence of fiber composition	299
Hemicellulose and swelling	299
Beating of alpha-cellulose	300
Influence of intrinsic strength	300
Effects of fiber length	301
Lubricating action of pulp	301
Theories of bar action	301
Bar pressure and clearance	302
Power input	302
Speed of bars	303
Bar widths	303
Number and spacing of bars	304
Sharpness of bar edges	305
Bar slope and angle	305
Bar material	305
Stainless steel and bronze bars	308
Stone, and unusual fillings	308
Influence of pulp on bars	309
Temperature	309
Influence of hydraulic pressure	309
Effect of pH	310

Separate beating	311
Miscellaneous beating phenomena	311
Formulas for beating action	311
Value of the formulas	312
Efficiency of beating	312
Summary	313
References	316

14.

Laboratory beating 317

Purpose of laboratory beating	317
Beating to maximum strength	317
Beating to a fixed freeness	318
Beating according to mill practice	318
Requirements for a laboratory beater	319
Laboratory disintegrator	319
Waring blender	319
Lampen mill	320
Jokro mill	322
PFI mill	322
Ball mills	323
Ultrasonic treatment	324
Aylesford laboratory beater	324
Mead refiner	325
Small refiners	326
Valley beater	326
Valley beater surveys	327
Valley beater standardization	328
Italian survey of lab beating apparatus	329
Finnish survey of lab beating apparatus	329
Morphologic differences after beating	331
Laboratory Kollergang	331
Kollergang reproducibility	333
Reproducibility with different operators	334
Simulating mill action	334
Objections to the Kollergang	335
Kollergang and mill treatments	335
Kollergang vs disk and claflin refiners	343
Kollergang vs various mill equipment	343
Kollergang and Valley beater tests	347
Reduced roll pressure and PFI tests	349
Pulp differentiation with Kollergang	351
Plotting beating curves	354
Linearity of plots	354
Two faulty forecasts	355

Kollergang procedure	356
<i>Test specimens</i>	356
<i>Procedure</i>	356
<i>Disintegration</i>	356
<i>Beating periods</i>	357
<i>Processing</i>	357
<i>Clearing</i>	358
<i>Dilution</i>	358
<i>Sheet making and testing</i>	359
Summary	359
References	361

15.

Test sheet making 363

Sheet molds	363
British apparatus and method	363
Acceptance elsewhere	364
Soaking	366
Disintegrating	366
Disintegrating mechanical pulps	367
Forming the sheets	368
Drainage time	368
Couch blotters	370
Couching	370
Aircouching	371
Advantages of air couching	372
Pressing	373
Drying	375
Plate vs machine drying	376
Making duplex test sheets	377
Replacing wire of sheet mold	377
Summary	378
References	379

16.

Hand sheet testing 380

Basisweight	380
Dryness factors	380
Light scattering coefficient	381
Specific volume (bulk)	381
Air permeability, capillarity, and bulk	382
Bursting strength	383
Improved clamp for bursts	384

Air operated bursting instruments	387
Nature of the bursting test	388
Cutting test pieces	389
Tensile and stretch	390
Tearing strength	391
Nature of the tearing test	391
Effect of beating on tear	392
Rubbing effect on tear test	392
Evaluation of tearing strength	392
Folding endurance	393
Sensitiveness of folding test	393
Schopper folding tester	393
Kohler-Molin tester	394
Modes of folding	394
Reduction of tensile by folding	396
Deficiency of present standard folding methods	396
Zero-span tensile strength	398
Roughness	398
Miscellaneous handsheet tests	398
Summary	399
References	400

SECTION

III

Fiber properties and tests

17.

Fiber length 402

Numerical average length	402
Numerical vs weight average fiber length	402
Fiber classification by weight	403
Development of classifiers	404
Vertical stationary screen classifier	405
Rotating 2-screen classifier	407
Rotating 4-screen classifier	407
Mechanism of fiber classification	407
Compartmental fiber lengths	409
Design factors affecting classifiers	411
Repeatability	412
Sharpness of length separation	412
Influence of classification period	413
Comparison of classifier results	415
Screen blockage and surface roughness	416
Rotary fiber classifier	416

Fiber length by visual analysis	416
Modified length-measuring methods	418
Precision needed for measurements	418
Effect of debris on length measurements	419
Removing the debris	419
Dyeing the fibers	420
Depositing the fibers	421
Preparing slides for projection.....	422
Measurements by tracing wheel	422
Boundary of field for measurements	423
Measurements by grid crossings	424
Verification of grid-count method	424
Grid spacing	425
Grid-crossing counting	425
Modified grid-counting method	426
Suggested standard calculations for fiber length	426
Weight and length average lengths	428
Fiberlengthsandcoarseness	431
Effect of length only	431
Effects of length with cut rayon fibers	431
Supposed effects of fiber length	433
Value of classification data	433
Grid plate for index of fiber length	434
Fiber-length index with classifier	434
Summary	435
References	436

18.

Fiber coarseness 438

Coarseness of fibers	438
Importanceofcoarseness	438
Some effects of fiber coarseness	439
Early methods	439
Ratios of fiber dimensions	440
Fiber wall thickness	440
Development of a coarseness measurement	441
Proportionality formula	441
Experimental checks of formula	442
Modified method for coarseness	442
Procedure for coarseness specimen	443
Counting the crossings	443
Calculations	444
Ranger's procedure for coarseness	444
Accuracy of repetition	445
Coarseness of wood fibers	445
Coarseness by weighing	445

Coarseness and weight factors	446
Effects of beating on coarseness	447
Coarseness of groundwood fibers	448
Summary	448
References	449

19.

Intrinsic fiber strength 450

Fiber strength	450
Tensile strength of fibers	450
Early zero-span tests	452
Improved zero-span attachments	453
Gripping pressure	454
Wear of jaw tips	455
Misalignment corrections	455
Effect of rate of loading	456
Effect of basis weight	456
Effect of small spans	458
Ratio of zero-span to fiber tensile strength	460
Zero-span tensile and pulp degradation	460
Zero-span vs DP	461
Zero-span tensile and maximum strength after beating	462
Normal and zero-span tensile ratios of test sheets	462
Summary	462
References	463

20.

Cohesiveness 465

Inplane cohesiveness	465
Shear stresses	465
Transverse cohesiveness	466
Dynamic transverse bonding test	467
"Percent adhesion"	467
Effect of fines and pressing	469
Ratio "adhesion" to cohesion	469
"Bonding index"	469
Shear separation of duplex sheets	470
Split separation of duplex sheets	472
Development of the shear method	472
Cohesiveness of acid treated sulfate pulp	473
Cohesiveness of acid treated sulfite pulp	477
Peel method procedure	477
Effects of gum and of soap	478
Bond fracture and light scattering	480
Cohesion of individual fibers	480

Control testing	480
Summary	481
Appendix: cohesiveness of pulp (shear test)	482
References	487

21.

Wet fiber compactability 488

Influencing factors	488
Measurement by hydraulic shear	488
Wet fiber compactability ratio	489
Compression and recovery of wet mats	489
Wet specific volume	490
Dry specific volume (bulk)	491
Essential test requirements	491
Improper test methods	492
Drying test sheets with heat	492
Shrinkage of test sheets	493
Bulk and paper machine operation	493
Bulk and paper evaluation	494
Bulk vs beating	494
"Solid fraction" and bulk	4%
Fiber density	4%
Changing bulk by pressure	497
Straight line relationships	497
Bulk as basis for beating curves	499
Basis for the comparison of pulp test sheets	500
Bulk and fiber-water properties	500
Conclusion	501
Summary	501
References	502

22.

Drainage of water from pulp 504

Water removal by paper machines	504
Crushing	505
Action of table rolls	505
Action of foils	506
The movement of debris	506
Dewatering in cylinder or twin-wire machines	507
Effects of beating on drainage	507
Freeness	508
Klemmtester	509
Skark apparatus	510
Divided funnel types	510

Reproducibility of CSF tests	512
Reproducibility of bulk tests	512
Freeness vs bulk for beater evaluation	513
Drainage timers	514
Drainage time with sheet mold	515
Standard drainage time procedure	516
Relation between drainage time and CSF	517
Drainage factor	518
Comparison of drainage times and factors	519
Miscellaneous drainage testers	521
Continuous freeness meters	522
A freeness and consistency recorder	524
Effects of debris on pulp and paper properties	527
Fourdrinier wire factors influencing drainage	528
Water retention value of pulps	529
The value of freeness tests	529
Summary	530
References	532

23.

Surface measurements 533

Areas of fiber surfaces	533
Specific surface by permeability	533
Hydrodynamic specific volume	534
Specific surface by silvering	535
Miscellaneous methods for surface	537
Permeability and freeness	538
Internal specific surface	539
Summary	539
References	540

24.

Wet-web strength 541

Early tensile measurement	541
Early burst measurement	541
Brecht's tensile apparatus	542
Effect of fiber slenderness	542
Effect of beating	543
Influence of solids content	543
"Critical" solids content	546
Strength of classified fractions	546
Fines and fiber mixtures	547
Wet rupture energy (WRE)	547
Stress-strain curves	548
Shape of stress-strain curves	549

Influencing factors	550
Force for 3 1/3% stretch	551
Apparatus for fixed stretch	551
Outline of fixed stretch method	553
Summary	555
Appendix: wet-web strength of pulps	556
References	558

SECTION

IV

Control and analysis

25.

Control of beating and refining 560

The evaluation of pulps	560
Determining requirements	560
The critical tests for stock	561
Problem of additives	561
Other advantages of stock tests	562
Beatability of pulps	562
Beating effects	563
Beating control	563
Subjective beating control	563
Control by classification	564
✓ Freeness control	564
Sampling stock for test	565
Drainage time tests	565
Additional control tests	566
Automatic indicators	566
Summary	567

26.

Efficiency of refiners and systems 569

Previous experiences	569
Beating effects	570
Desired stock characteristics	570
Analyzing the actions	571
Measuring the effects	572
Reduction of fiber length	572
Internal fibrillation	573
External fibrillation	574

Practical examples	574
Direct comparison of refiners	576
Usefulness of beating units	577
Summary	577
References	578

27.

Characterization and control of mechanical pulps 579

Standard evaluation	579
Fundamental characteristics	579
Intrinsic strength	581
Wet compactability	581
Beatability	581
Cohesiveness	583
Ozonation and cohesiveness	584
Stone and refiner pulp differences	584
Fiber length and slenderness	585
Accurate measurement of fiber length	585
Length distribution data	586
Mixtures of pulps or components	586
Properties of fractions	587
Routine length measurements	589
Routine slenderness measurements	590
Apparatus for modified method for slenderness	591
Procedure for fiber length	592
Procedure for fiber slenderness	593
Some relationships between properties	594
Further relationships	594
"Latency"	595
Release of "latency"	597
Difficulties with freeness	597
Blue glass test	598
Other subjective tests	598
Quick control procedure	598
Drainage time	599
Sheet tests	600
Summary	601
References	601

28.

Chemical and microscopical analysis 603

Hemicellulose and strength	603
Composition of fibers	603

Hardness tests	604
✓ Kappa number	604
Cellulose purity—alpha-cellulose	605
Beta- and gamma-cellulose	605
Hemicellulose	606
Copper number	606
Degree of polymerization (DP)	606
Solubility in dilute alkali	607
Pitch content	607
Pitch deposition	608
Pitch tests	608
Miscellaneous chemical tests	609
Fiber analysis	609
Permanence of paper	609
Lignin in pulp, paper, or wood	610
Chemical analysis for groundwood content	611
✓ Microscopical analysis	611
Stain for beaten fibers	612
Summary	612
References	613

29.

Optical characteristics, dirt, and shives 614

Reflection and refraction	614
Internal reflection	615
Diffusion of light and opacity	616
Scattering and absorption	617
Reflectance	617
Printing opacity	619
Brightness	619
Sheets for optical tests	620
Measurements of brightness	620
Color	623
Definition of dirt	624
Equivalent black area (EBA)	625
Method for EBA	626
Criticisms of EBA method	627
Exposed and total dirt content	627
Dirt survey in mill	629
Translucent dirt count methods	629
Ranges of speck sizes	629
Automatic dirt scanners	630
Kinds of dirt	630
Shives	630
Measuring shive content	632
Laboratory screens	632
Von Alftan shive analyzer	633

Mini-shive analyzer	634
Optical shive analyzer	635
Visual analysis of shives	635
Summary	637
References	638

30.

Raw materials for pulp 639

Availability of raw materials	639
Suitability of raw materials	640
Evaluation of raw materials	641
Evaluation by pulping	641
Yield	644
Intrinsic strength	644
Fiber length	644
Fiber "width" and perimeters	645
Coarseness	646
Assessment of new materials	647
Length-width ratios of fibers	648
Recommended preliminary data	649
Variability of raw materials	649
Wood and growing conditions	649
Fibrous materials other than wood	651
Cotton and linters	652
Linen	652
Hemp	653
Jute	653
Bamboo	653
Straw	654
Esparto	655
Bagasse	655
Miscellaneous fibers	656
Waste paper	656
Effects of repulping paper	657
Changes caused by drying pulp	657
Changes to repulped paper fibers	659
Degradation of repulped fibers	660
Fiber solidification	660
Summary	661
References	663

31.

Filling and bonding materials 664

Fillers	664
Early use of fillers	664

China clay	665
Different clays	665
Clay and associated water	666
Calcium carbonate	666
Titanium dioxide	667
Talc	667
Particle size	667
Fillers and bonding	668
Primitive use of bonding agents	668
Cohesion by fibrillation	669
Mechanism of supplemental bonding	669
Starch	670
Optimum cooking of starch	670
Cationic starch	670
Gums	671
Effect of fibrillation	671
Gel and raw fiber combinations	671
Hemicelluloses	673
Miscellaneous bonding additives	674
Ionic and covalent bonding	674
Alum	676
Summary	676
References	678

SECTION

V

Practical considerations

32.

Formulas for pulp properties 680

Correcting deficiencies	680
Page formula for tensile strength	680
Modified Page formula	681
Confirmation of modification	682
Fiber length, bulk and sheet strength	683
Varying coarseness and length	687
✓ Breaking length	688
Rigidity factor	688
✓ Burst factor	688
Tear factor	689
Fold	690
Bulk	691
✓ Zero-span tensile and cohesiveness	692
Expanded formulas	692

Limitations of the formulas	694
Tensile fracture	694
Burst fracture	695
Tearing resistance	695
Folding endurance	696
Use of formulas	697
Summary	697
References	698

33.

Pulp and paper relationships 699

Pulp properties	699
Beating	699
Definitions	700
Stock properties	700
Effects of stock on machine operation	702
Fiber aggregation	702
Drainage and crushing	703
Formation	704
Wet-web strength	705
Machine effects on paper properties	705
Stretch	705
Stretch and strength	707
Transverse tensile strength	708
Fuzz	708
Erasing ability	708
Curl, cockle, and waviness	708
Miscellaneous paper qualities	709
Specific stock requirements	709
Summary	709
References	710

34.

Humidity and control rooms 711

Measurement of relative humidity	711
Humidity hysteresis	712
Relative humidity standards	712
Advantages of 50% vs 65% RH	713
Effects of hysteresis	714
Tests at 65% and 50% RH	715
Effects of temperature	716
Constant humidity rooms	716
Dew point control rooms	716
Corrective control rooms	717
Corrective control systems	719

Corrective control advantages	721
Summary	721
References	722

35.

Tests and testing data 723

Accuracy and precision	723
Applicability of tests	723
Misapplied pulp tests	724
Usefulness of definitive tests	724
The formulation of tests	725
Reproducibility of tests	726
Reliability of tests	726
Checking testing operations	726
Representative sampling	727
Recording test data	727
Rule for number of digits	728
Application of statistics	729
Variability of results	729
Degree of confidence	730
The value of statistics	731
Cooperative standardization	731
Summary	732
Reference	732

36.

Collection and filing of data 733

Example of the system	733
System for beginners	733
Changes and expansions	736
Choosing the appropriate folder	736
The end	737
Summary	737
References	738

Envoi 739

Author index 740

Subject index 745

Conversion table for SI units 752