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AEROSPACE STANDARD

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Superseding ARP755B

Aircraft Propulsion System Performance Station Designation and Nomenclature

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1. SCOPE:

1.1 This SAE Aerospace Standard (AS) provides performance station designation and nomenclature systems for aircraft propulsion systems and their derivatives.

1.2 The systems presented herein are for use in all communications concerning propulsion system performance such as computer programs, data reduction, design activities, and published documents. They are intended to facilitate calculations by the program user without unduly restricting the method of calculation used by the program supplier.

1.3 The list of symbols presented herein will be used for identification of input and output parameters. These symbols are not required to be used as internal parameter names within the engine subprogram.

2. REFERENCES:

There are no referenced publications specified herein.

3. STATION DESIGNATION:

The following station numbering system will be used to designate the points in the gas flow path that are significant to propulsion system performance definition.

For computer symbols in this document, the following convention will be used:

a. Ø denotes the numeric symbol
b. O denotes the alphabetic symbol

WARNING: This convention is reversed from ARP755A, but consistent with later revisions.

3.1 Basis of System:

The system provides for the consistent definition of the process being undergone by the gas, regardless of the type of engine cycle. The six main processes specifically isolated are:

a. kinetic compression (inlet/diffuser)
b. mechanical compression/work addition/fluidic compression (compressor/propeller)
c. heat addition or exchange (combustor/augmentor/heat exchanger)
d. mechanical expansion/work extraction (turbine)
e. kinetic expansion (nozzle)
f. mixing (mixer/ejector/eductor).

3.2 Primary Stream:

The station numbers required to identify the processes for the primary gas flow are:

a. Ø Free stream air conditions
b. 1 First station of interest to the engine manufacturer, e.g., propulsion system entrance or external/internal interface
c. 2 First compressor front face
d. 3 Last compressor discharge or burner entrance
e. 4 Burner discharge or first turbine entrance
f. 5 Last turbine discharge
g. 6 Available for mixer, afterburner, etc.
h. 7 Engine/exhaust nozzle interface
i. 8 Exhaust nozzle throat
j. 9 Exhaust nozzle discharge

Station numbers associated with missing processes should be eliminated. Numbers not used for processes identified in 3.2 should not be utilized for other processes.

3.3 Multiple Streams:

Extension of the primary flow numbering scheme to multiple streams (e.g., the bypass flow of a turbofan engine) is obtained by prefixing a digit to the numbers in 3.2.

3.3.1 Unity (1) will be used for the innermost bypass stream with each succeeding stream numbered in consecutive order to the outermost stream.

Examples: 12 First compressor front face tip portion (if different from Station 2)
13 End of compression of bypass flow
28 Second bypass stream exhaust nozzle throat

3.3.2 Previous practice has been to use a leading digit 9 to identify the second bypass stream or an ejector nozzle flow, with the digit 8 for a third bypass stream, etc. While consecutive numbering is preferred, the previous practice is still acceptable, since it might create less confusion in engines having multiple compressor stations in the primary stream.

Examples: 93 Compressor discharge in 2nd bypass stream
83 Compressor discharge in 3rd bypass stream

3.3.3 If, however, two or more flow paths are mixed, succeeding numbers will be consistent with the innermost stream. For example, primary flow numbers are to be used when primary flow is mixed with a bypass flow.

3.3.4 The first digit of the primary stream and the first two digits of additional streams will be numeric only.

3.3.5 Property values (or flow rates) for individual streams are always average (or total) quantities.

Where primary and bypass streams are differentiated by separate stations and there is a need to describe the average (or total) properties at a plane including both streams, an alphanumeric station will be created. This station will be coplanar with the primary and bypass stations and formed by appending a letter to the hub station identification.

Appendage of the letter A, e.g. 1A, is reserved to describe the combined properties of all the streams in that plane. For example, when stations 1 and 11 define the primary and bypass streams at the engine inlet interface, station 1A is defined as encompassing both stations 1 and 11. More than two streams can be handled in a similar manner.

3.4 Intermediate Stations:

For identification of intermediate stations, numeric or, if necessary, alphabetic subdividers will be appended to the upstream station numbers in 3.2 and 3.3. The appended subdivider should, where possible, be limited to one additional digit which will be chosen to prevent duplication, and will be assigned in an ascending or alphabetic sequence which corresponds to the direction of flow.

When using numeric subdividers, the use of a decimal point separator is encouraged to avoid confusion with multiple stream designators. The use of a decimal point may be incompatible with some computer languages. In such a case, it may be omitted or replaced by some other distinguishable character. A station between a primary stream low and high pressure compressor could be shown as 2.5 (preferred), 25, 2_5 or 2$5 for instance.

If the length of the station designator is restricted so as to make use of a separator character undesirable, an alphabetic subdivider would be appropriate for multiple stream propulsion systems. For example, a primary intermediate station between stations 1 and 2 for a bypass engine may be identified as 1B to avoid conflict with the innermost bypass duct first compressor front face tip section, station 12.

3.5 Propeller Stations:

Special considerations are involved for engines with propellers or propulsors. The engine manufacturer may not have responsibility for the propeller system. When data or cycle decks are furnished, the engine manufacturer may create station numbers without regard to the propeller. Propeller stations may, therefore, be distinct from those of the engine, while following the same general principles.

Propeller station designations should conform to the rules used for engines, but may contain the suffix "P". The propeller upstream station thus becomes 12P. For that portion of the airflow at the hub which also flows through the gas generator, the upstream station becomes 2P.

For intermediate stations in a counter-rotating propeller system, the station designations become 12xP and 2xP, respectively, where a numeral would be substituted for the embedded symbol "x". The downstream stations become 13P and 3P.

3.6 Rocket Stations:

Special considerations are also involved for airbreathing powerplants which make use of rocket components, such as ducted rockets or ejector ramjets. One powerplant manufacturer may not have responsibility for the entire system. Rocket stations may, therefore, be distinct from those of the airbreathing portion of the system, while following the same general principles.

Rocket station designations should conform to the rules used for engines, but may contain the suffix RK.

3.7 Figures:

Figure 1 shows how these conventions can be applied to various pusher or tractor propeller systems. Figure 2 shows examples of the application of this system to several typical gas turbine engine configurations. Figure 3 shows examples of this system applied to other aircraft propulsion systems.

4. NOMENCLATURE:

This nomenclature has been compiled to provide a uniform method of naming variables associated with airbreathing propulsion systems. Its use is encouraged for all communications involving propulsion system performance including computer programs.

There are two columns of symbols. The first column presents the recommended symbols for general use and is restricted to upper case letters to be compatible with the computer. The second column presents alternate symbols which are retained because of their widespread use. Lowercase letters, subscripts and superscripts, Greek letters and other specialized characters have been avoided in the recommended symbols.

4.1 Basic Symbols:

This section includes the symbols used to derive basic parameters and will normally form the leading letter, or letters, in compound groups. Most of these symbols will be expanded by the addition of a station number, component symbol or stream identification as contained in later paragraphs. Examples of some resulting compound groups are contained in Section 5.

4.1.1 Properties and Fundamental Parameters: Please note that in all sections of this document the alternate form of the symbol is in parentheses.

Area, geometric	A	
Altitude (Geopotential pressure)	ALT	
Angle	ANG	(AN, α, β, γ, etc.)
Density	RHO	(ρ)
Efficiency, adiabatic	E	(η, ETA)
Enthalpy - total per unit mass	H	
Entropy - total per unit mass	S	
Force, Thrust	F	
Frequency	FY	(f)

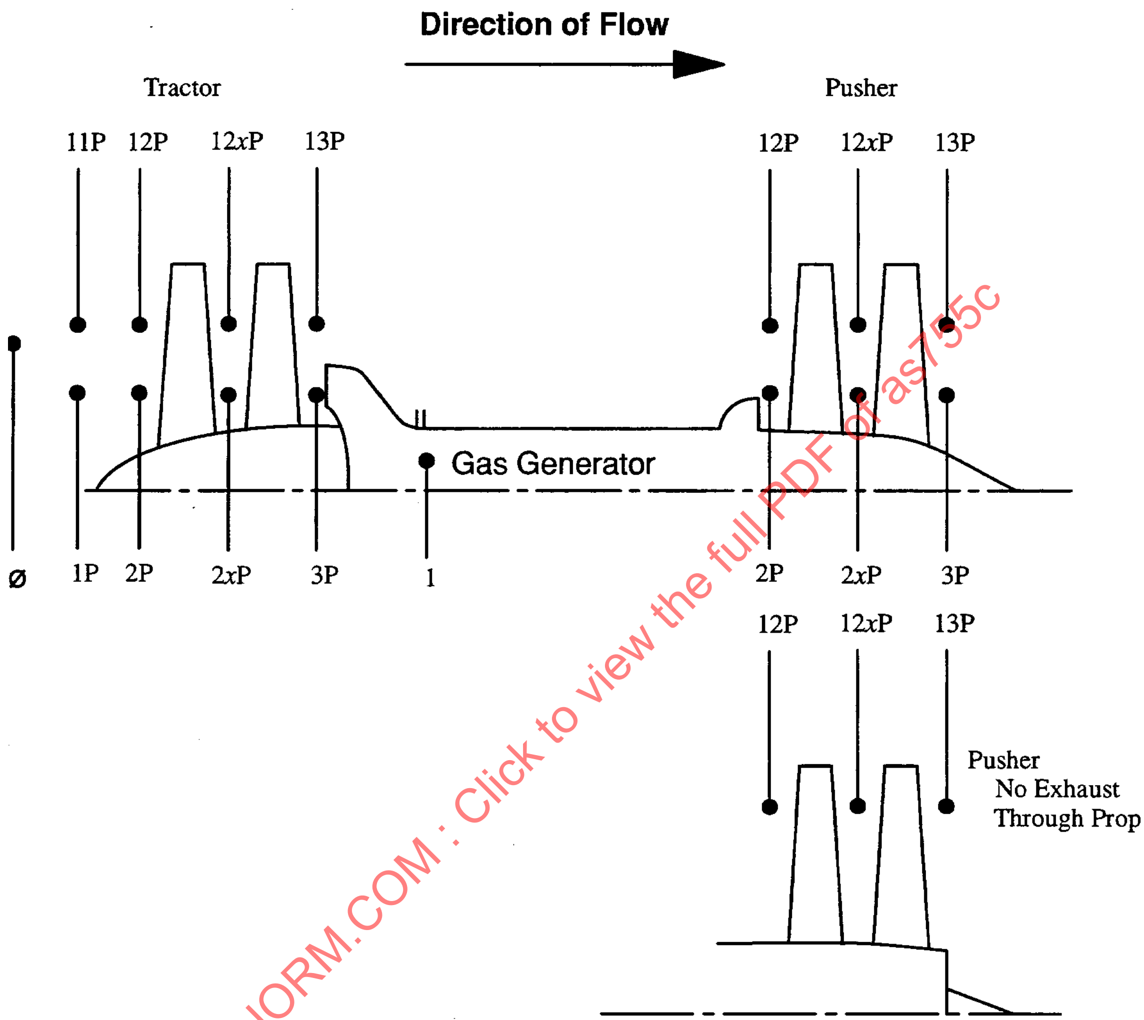


FIGURE 1 - Propeller/Propfan/UDF/Ultra-Bypass/Ultra-High Bypass Station Designations (Reference Section 3)

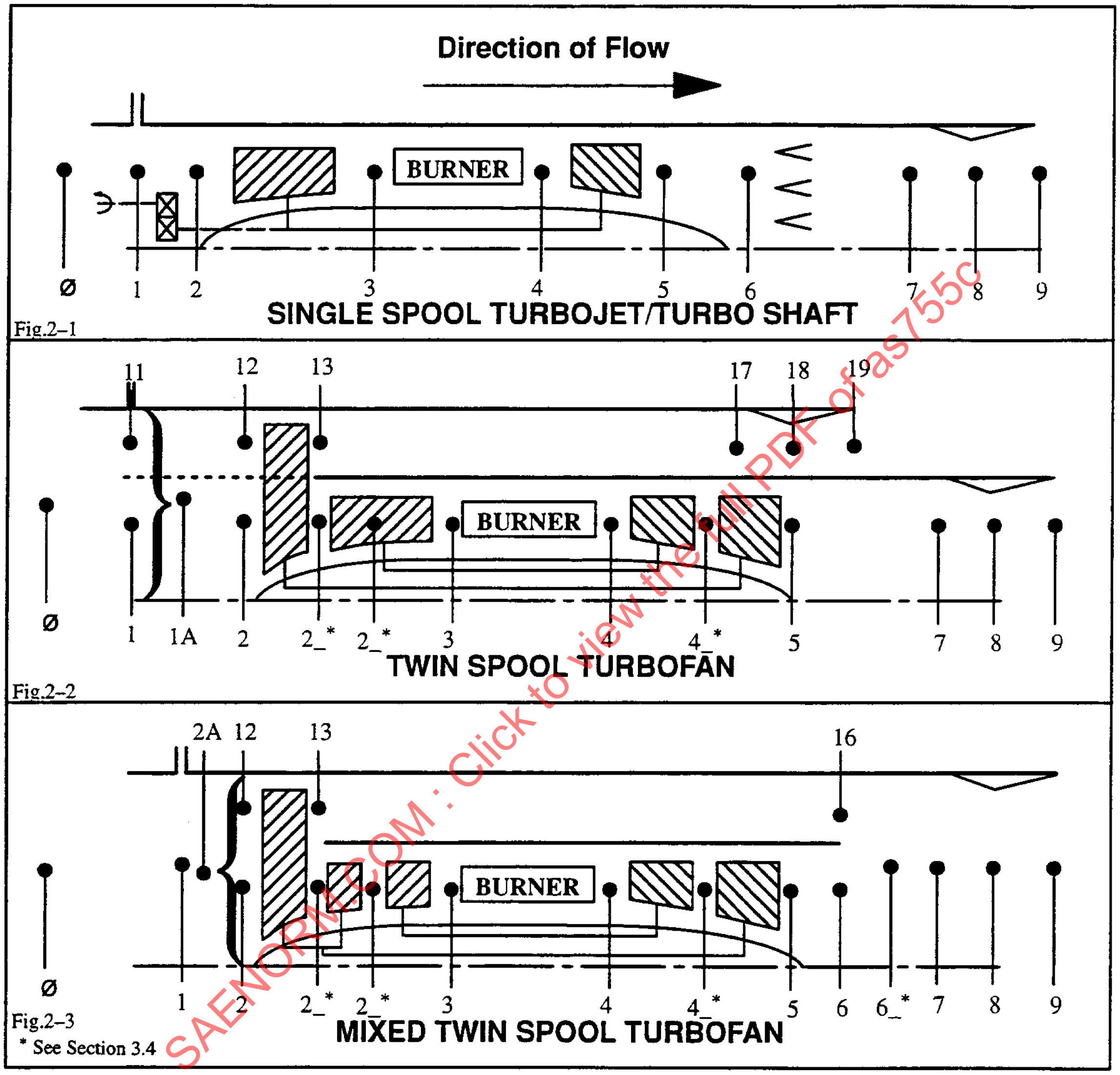


FIGURE 2 - Examples of Station Designation for Gas Turbine Engines
(Reference Section 3)

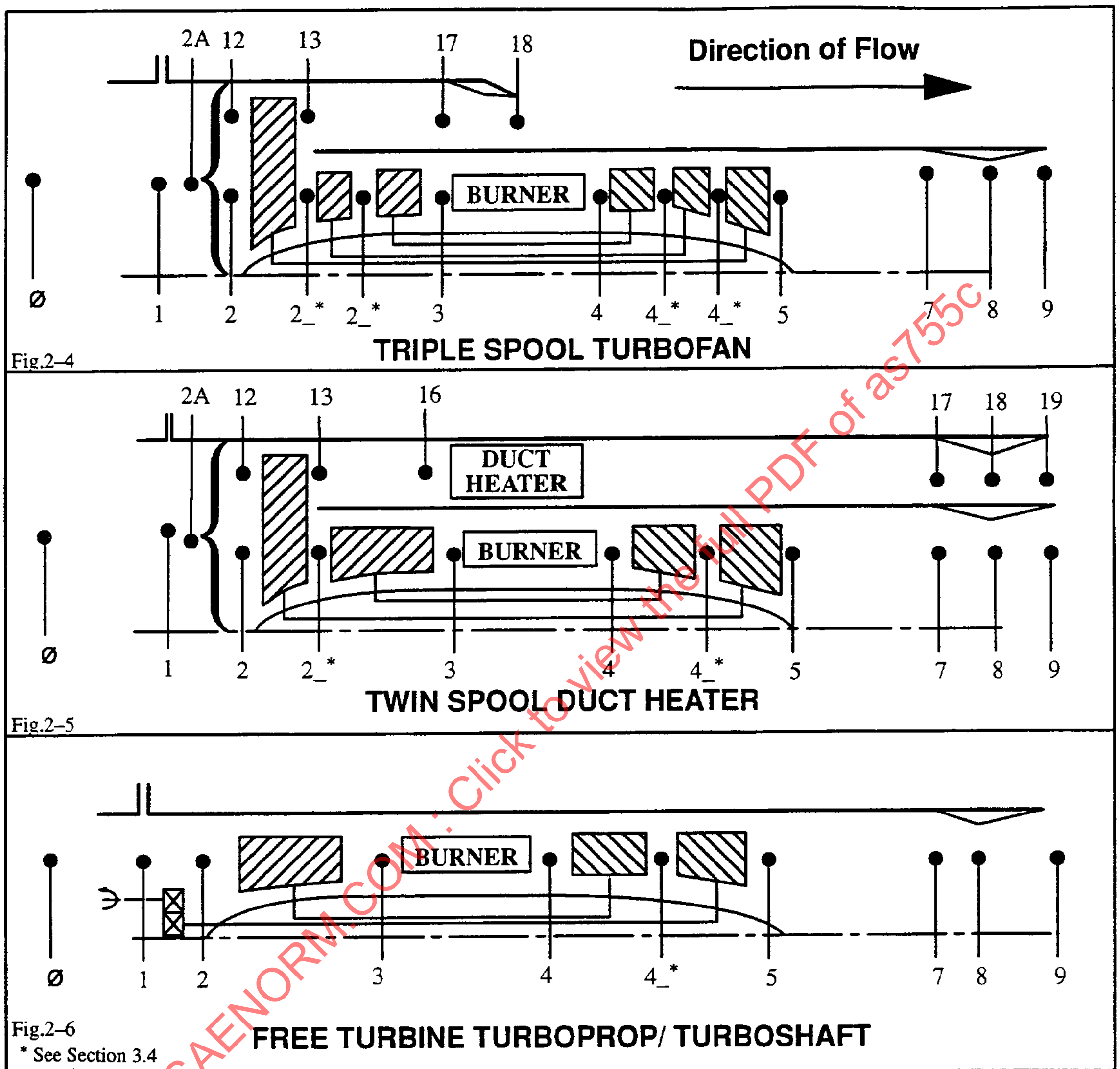


FIGURE 2 (Continued)

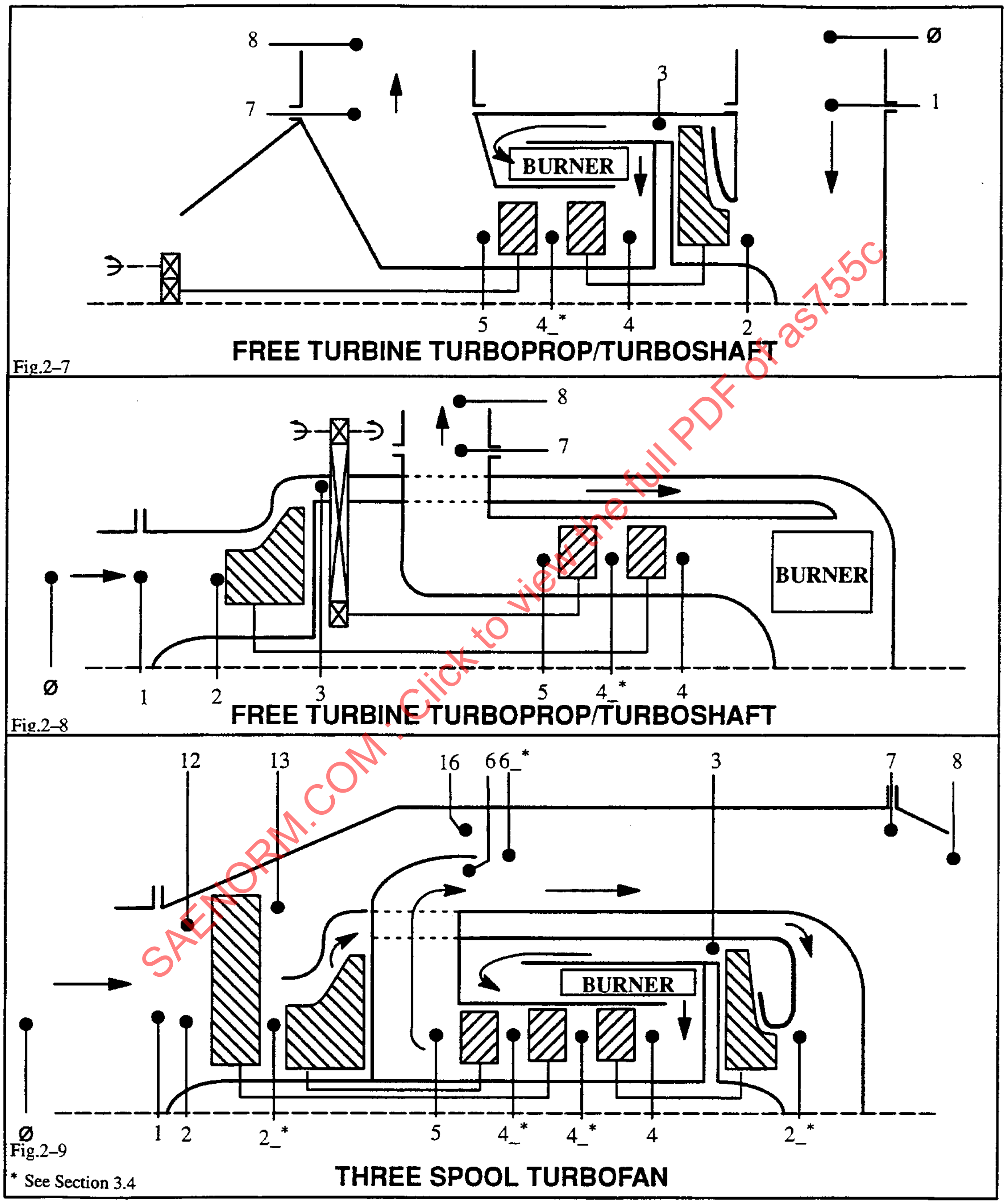


FIGURE 2 (Continued)

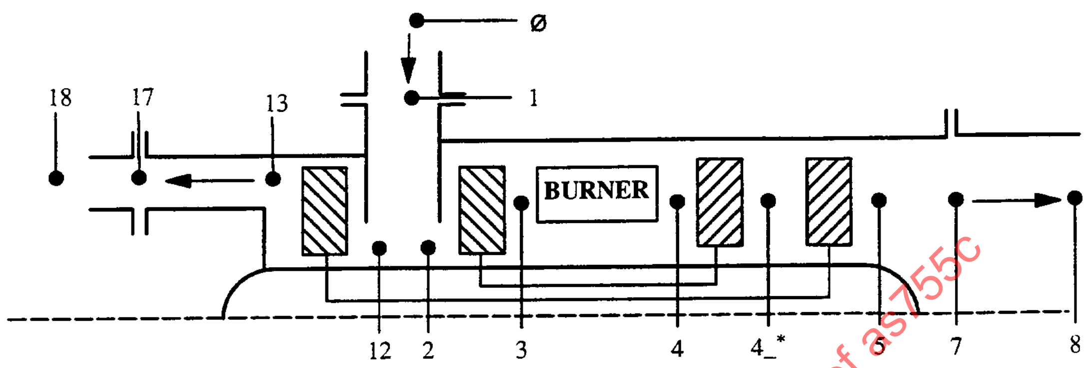
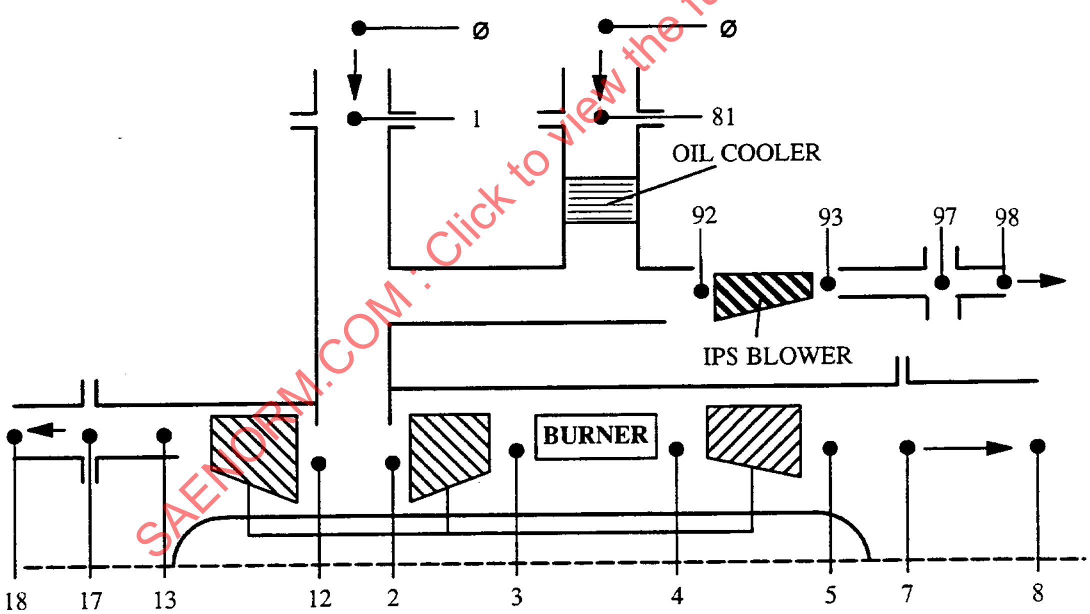


Fig.2–10

AUXILIARY POWER UNIT
(Independent secondary compressor drive)



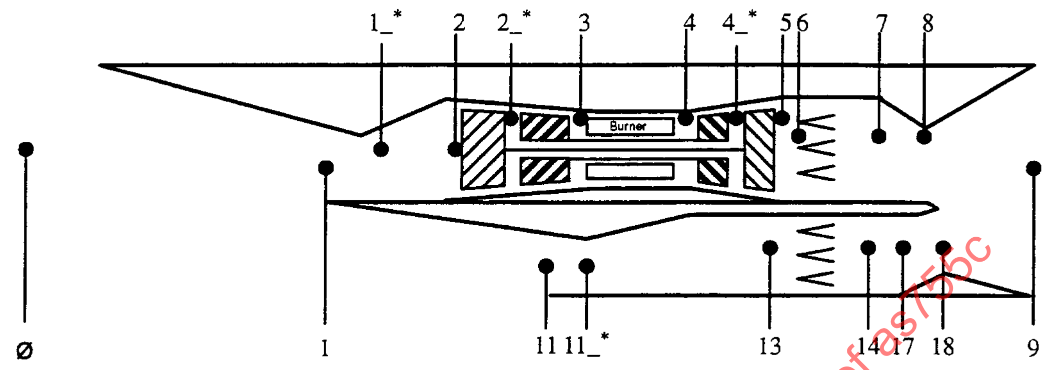
Note: The station numbering in this figure illustrates the convention used in past practice for numbering multiple streams for older computer languages, per para. 2.3.2.

Fig.2–11

* See Section 3.4

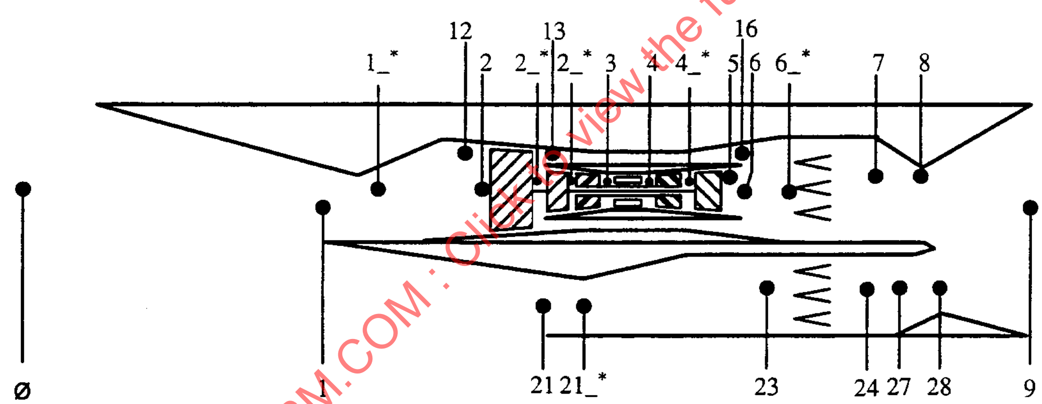
AUXILIARY POWER UNIT
WITH 2 STREAM INLET PARTICLE SEPARATOR

FIGURE 2 (Continued)



OVER/UNDER TURBORAMJET

Fig. 3–1



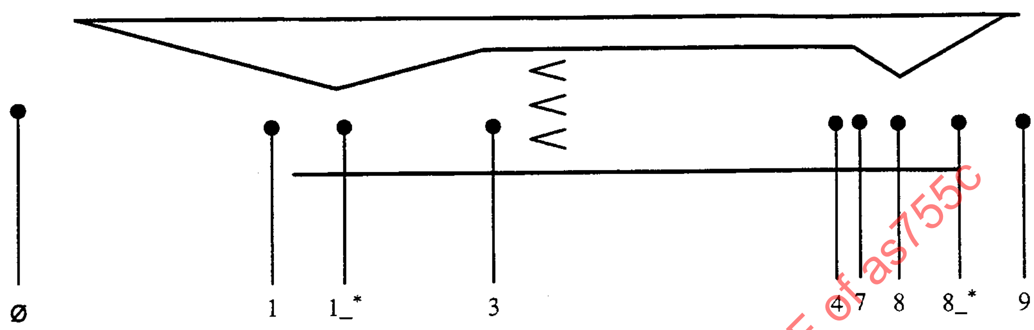
Note: The numbering of stations in the compression section of the turbofan vs. those of the ramjet section might have to be treated differently in older computer languages to prevent confusion.

Fig. 3–2

OVER/UNDER TURBOFAN RAMJET

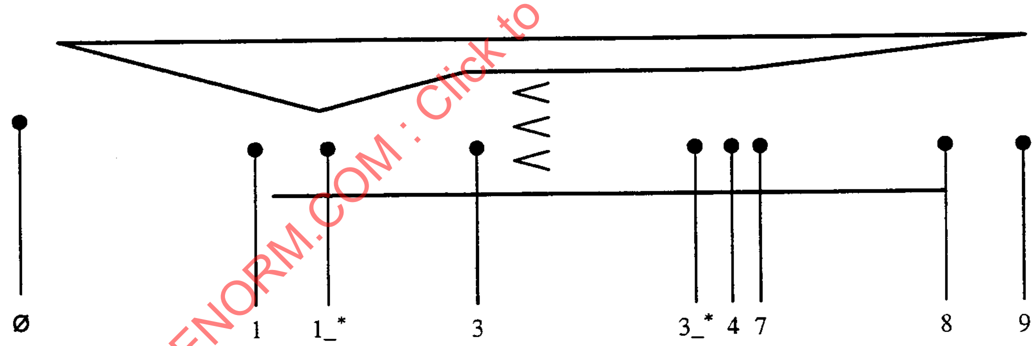
* See Section 3.4

FIGURE 3 - Examples of Station Designation for Other Airbreathing Propulsion Systems (Reference Section 3)



MECHANICAL CHOKE RAMJET

Fig. 3–3



THERMAL CHOKE RAMJET

Fig. 3–4

* See Section 3.4

FIGURE 3 (Continued)

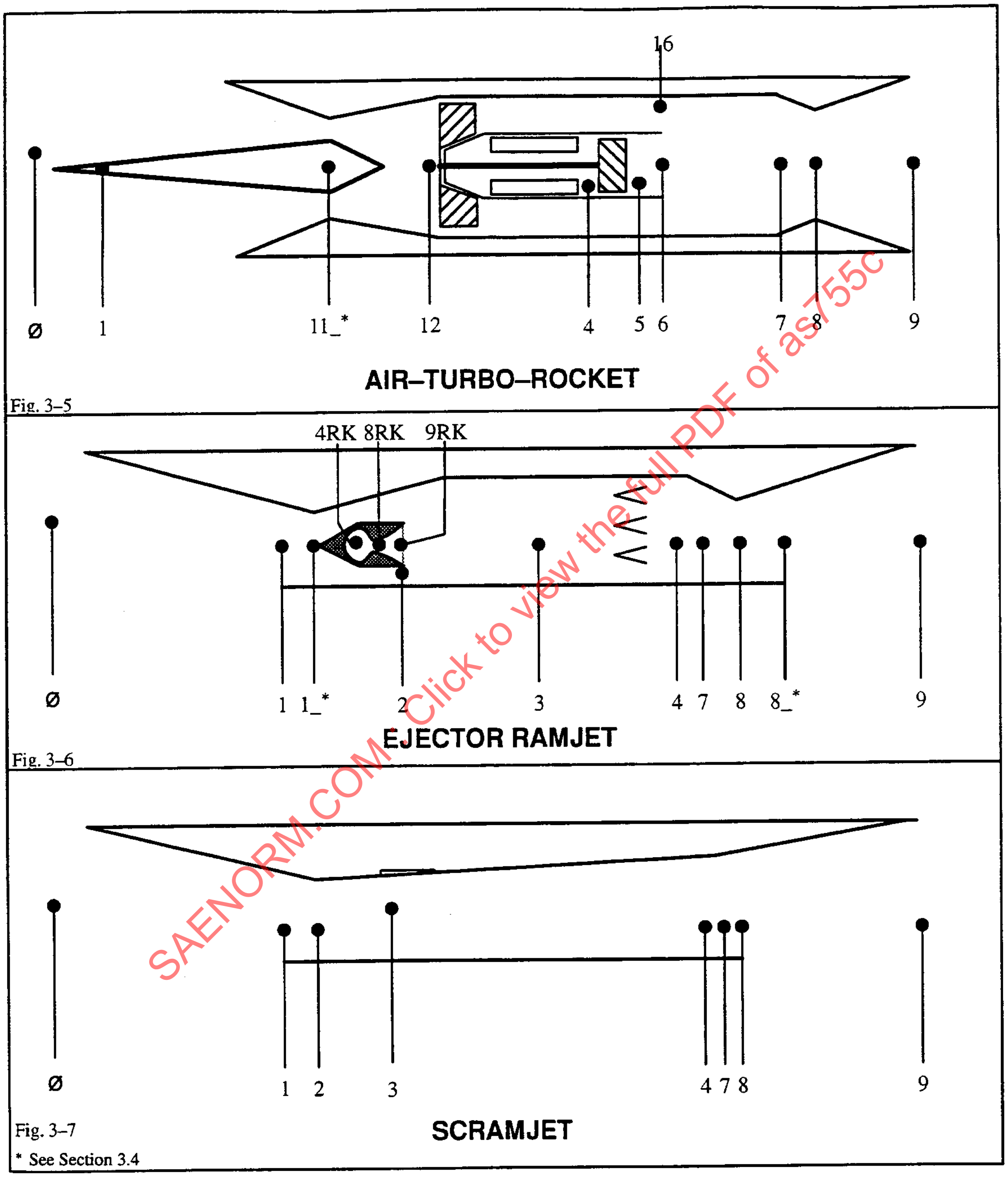


FIGURE 3 (Continued)

4.1.1 (Continued):

Heat Transfer Rate	QU	(Q)
Inertia - polar moment (see 4.4.3)	J	(XJ)
Length	L	(XL)
Mass	GM	(m)
Mass flow rate	W	
Power	PW	
Pressure - total	P	
Rotational speed	N	(XN)
Temperature - total	T	
Time	TIME	(t)
Torque	TRQ	
Velocity	V	
Viscosity	VIS	
Volume	VOL	(v)
Weight	WT	(w)

4.1.2 Commonly Used Ratios, Functions, etc.: This paragraph contains symbol groupings which, although they are exceptions to the general system, have been retained because of their widespread use in industry.

Blow-out margin	BOM	
Bypass ratio	BPR	
Coefficient or constant	C	
Delta (pressure/std. SLS pressure)	DEL	(δ)
Discharge coefficient	CD	
Drag	FD	
Emissions index	EI	
Engine pressure ratio	EPR	
Entropy function	PHI	(ϕ)
Error	Y	
Exhaust gas temperature	EGT	
Fuel: Air Ratio	FAR	
Fuel lower heating value	FHV	
Fuel specific gravity	SGF	
Gas constant (per unit mass)	R	
Input or given parameter value	Z	
Light-off margin	LOM	(XLOM)
Mach number	M	(XM)
Mechanical equivalent of heat	CJ	
Molecular weight	MW	(XMW)
Power lever angle	PLA	
Propeller Advance Ratio	QJ	
Propeller Blade Angle	BETA	(β)
Ratio of specific heats	GAM	(γ)
Relative humidity	RH	

4.1.2 (Continued):

Reynolds number	RE	
Reynolds number index	RNI	
Rotor blade angular position	ROP	
Specific fuel consumption	SFC	
Specific gravity	SG	
Specific heat at constant pressure	CP	
Specific humidity	SH	
Surge margin	SM	
Stator Blade angular position	STP	
Tangential wheel speed	U	
Theta (temperature/std. SLS temperature)	TH	(θ)
Velocity dynamic head	VH	(q)
Velocity of sound	VS	(a)
Water (liquid): air ratio	WARL	
Water (vapor): air ratio	WAR	

4.2 Operating Symbols:

The letters in this paragraph describe operations and will normally be imbedded in compound groups.

Derivative with respect to time	U	(d/dt)
Derivative with respect to following symbol	U_	(d/d_)
Difference (see 3.4.2)	D	(- or Δ)
Quotient, Ratio-(when not followed by U)	Q	(/)
Square Root	R	($\sqrt{\ }$)

4.3 Descriptive Symbols:

This paragraph includes recommended symbols that describe the basic parameters and will usually be the trailing letter, or letters, in compound groups. It is subdivided into a section describing the fluid, a section containing symbols describing parts of the engine and a general section.

4.3.1 Fluid Description: Some properties and fundamental parameters (e.g., pressure, flow rate) which refer to the fluid may require additional description to indicate the composition and use of the fluid. The following letters should be appended directly after the basic symbols of 4.1 (see 4.4.1 for additional notes on fluid description).

Ai	A	
Bleed	B	
Boundary layer	BL	
Coolant	CL	(C)
Fuel	F	
Leakage	LK	(L)
Oxidizer	OX	
Water	W	

4.3.2 Engine Description:

4.3.2.1 Some parameters which refer to propulsion system components or turbine engine rotors (e.g., efficiency, rotor speed, surge margin, torque) require more specific description. This should be provided by appending the station number (see Section 3) at the inlet to the relevant component or rotor after the basic symbols of 4.1. An alternate method, included because of its widespread use in industry, is to append the following symbols:

Afterburner	AB
Boat-tail	BT
Burner	B
Compressor	C
Engine	E
Heat Exchanger	EX
Gearbox	GB
High pressure component or rotor	H
Intermediate pressure component or rotor	I
Low pressure component or rotor	L
Power turbine or rotor	PT
Turbine	T

4.3.2.2 Some propulsion system components may require specific identification. In these cases, the identifier should be appended to the station number:

Propeller	P	
Rocket	RK	(R)

4.3.3 General Description: The following general descriptive symbols should be appended after the basic symbols of 4.1:

Average	A	(AV)
Ambient	AMB	
Calculated	CAL	
Calibrated airspeed	CAS	
Conductivity	K	
Controlled variable	C	
Diameter	DI	
Distortion	DIST	
Effective	E	
Equivalent airspeed	EAS	
Extraction	X	
Gross	G	
High (maximum)	H	
Horizontal	HOR	
Hub	HUB	
Ideal	I	
Indicated airspeed	IAS	
Installed	IN	
Low (minimum)	L	
Map value	M	
Measured	ME	
Mixed	M	(MX)
Net	N	
Parasitic	PAR	
Per Cent	PCT	(PC)
Polytropic	P	
Radius	RAD	
Ram	RAM	
Referred (corrected)	R	
Relative	REL	
Reverse	REV	(RV)
Sea level	SL	
Sensed parameter	SE	
Shaft delivery (output)	SD	
Standard	STD	
Static	S	
Swirl	SW	
Tip	TIP	
Total	T	
True airspeed	TAS	
Vertical	VER	

4.4 Additional Notes:

4.4.1 To describe the position within the propulsion system of parameters associated with a fluid, the numbers detailed in the station identification system of Section 3 should be appended. The letters of 4.3.1 should precede these station numbers if both are required.

4.4.2 The imbedded D, which identifies a difference (see 4.2) should be used wherever the compound group of symbols is of an acceptable length. However, D may also be used as a leading symbol of a difference parameter when contraction of the compound group of symbols is necessary.

4.4.3 The symbol J (polar moment of inertia) should be appended by a component identification symbol (4.3.2). The component should be that to which all associated inertias are algebraically referred.

4.4.4 A gas property followed by S denotes a static quantity; otherwise a stagnation condition is implied.

4.4.5 The symbol X may be prefixed to leading symbols I, J, K, L, M, N for computer purposes.

4.4.6 It is recognized that it may be required to limit the number of characters per parameter name. When this limitation is not compatible with the recommended nomenclature of this document, the parameter name may be shortened. For a complex grouping, a leading G is recommended.

5. EXAMPLES:

Some examples of compound groups formed from recommended symbols are contained in this paragraph.

5.1 Examples of groups formed by basic symbols together with one or more descriptive symbols:

AE	Effective area
ANGBT	Boat-tail angle
ANGSW	Swirl angle
CF	Thrust coefficient
CFG	Gross thrust coefficient
CFP	Propeller thrust coefficient
CPSTD	Standard SLS pressure
CPW	Propeller power coefficient
CQU	Overall heat transfer coefficient
CQUBL	Heat transfer film (boundary layer) coefficient
CQUK	Thermal conductivity
CQUL	Coefficient of linear thermal expansion
CR	Universal gas constant
CTSTD	Standard SLS temperature
CV	Nozzle velocity coefficient
DTAMB	Ambient temp. minus ISA temperature
DPW	Unbalanced power
DTRQ	Unbalanced torque

5.1 (Continued):

EGB	Gearbox efficiency
EP	Polytropic efficiency
ERAM	Ram pressure recovery
ETAP	Propeller efficiency
FG	Gross thrust
FGI	Ideal gross thrust
FN	Net thrust
FNIN	Installed net thrust
FRAM	Ram drag
HF	Enthalpy of fuel
HS	Static enthalpy
NQGB	Gearbox speed ratio, relative to driving speed
NQP	Counter-rotating speed ratio of propellers
NSD	Delivered shaft speed
PAMB	Ambient pressure
PB	Bleed flow total pressure
PS	Static pressure
PWPAR	Parasitic power
PWQP	Power split in counter-rotating components, with respect to total power
PWSD	Delivered shaft power
PWX	Power extraction
SFCIN	Installed specific fuel consumption
TAMB	Ambient temperature
TLK	Total temperature of leakage gas
TRQSD	Delivered shaft torque
TS	Static temperature
UTIP	Tangential wheel tip speed
VANG	Angular velocity
VTAS	Aircraft velocity (true air speed)
WA	Airflow rate
WF	Fuel flow rate
WFT	Total fuel flow rate
WW	Water flow rate
XNSD	Delivered shaft speed, computer language alternate

5.2 Groups formed by basic symbols together with descriptive symbols and station numbers:

CD8	Primary nozzle flow discharge coefficient
CV8	Primary nozzle velocity coefficient
DT1	Temperature to be added to T1
FAR4	Fuel:air ratio at station 4
FG19	Bypass nozzle gross thrust
F7	Stream thrust at station 7
HA3	Total enthalpy of air at station 3
J2	Polar moment of inertia of spool containing low pressure compressor with all inertias of that component
N2H	Maximum low pressure compressor rotor speed
N21L	Minimum speed of rotor whose compressor inlet station is at station 21
PB3	Bleed flow total pressure at station 3
PS4QS3	Static pressure ratio; station 4 divided by station 3
PW4	High pressure turbine power
PØ	Free stream total pressure
PØQAMB	Isentropic ram pressure ratio
P1QAMB	Ram pressure ratio
P3	Total pressure at station 3
P3U	Time rate of change of total pressure at station 3
P4Q3	Total pressure ratio; station 4 divided by station 3
P6D7	Total pressure change from station 6 to station 7
TRQ2	Low pressure compressor torque
TSØSTD	ICAO Standard Atmospheric (ISA) temperature
T2UN2	Rate of change of T2 with respect to N2
T41	Turbine rotor inlet temperature (industry standard)
WA2	Airflow rate at station 2
WB3	Bleed flow rate at station 3
WLK3	Leakage flow rate at station 3
W1R	Referred engine inlet flow rate
W3R2	Flow rate at station 3 referred to station 2
XN2	Low pressure compressor rotor speed, computer language alternate

NOTE: Cockpit gauges use N1, N2 and N3 for per cent physical rotor speeds. Because of this, it is common in industry to use N1, N2, and N3 in cycle computer programs rather than having station number as part of the symbol. (In cycle computer programs, however, N is used as speed in rpm and not per cent.)