CHAPTER 10

AIRCRAFT SERVICES

_ INTRODUCTION

_ ENGINE ATTACHMENT

_ ACCESSORY DRIVE

_ P2 AIR TAPPING

_ AIR INTAKE DEVICE

_ JET PIPE

_ ENGINE CONTROL

_ CONNECTIONS

INTRODUCTION

This paragraph deals with the components allowing the installation of the engine on the aircraft.

In the case of the "ARTOUSTE III", installed on the ALOUETTE III helicopter, these components are provided by the aircraft manufacturer ; it is the reason why they will be considered very briefly only.

The chapter covers the following sections :

- Engine attachment
- Drives for aircraft services
- P2 air tapping
- Air intake
- Jet pipe
- Engine control
- Connections.

ENGINE ATTACHMENT

INTRODUCTION

The engine is installed on the aircraft by means of a mounting which consists of two attachment points at the front of the engine, and one attachment point at the rear.

DESCRIPTION

Engine front attachment

It consists of two flanges mounted on the plates located on the lateral surfaces of the support casing.

Rear engine attachment

It consists of a flat-plate provided with a stud at the lower rear part of the turbine casing.

Hoisting points

The engine hoisting is carried out by means of two rings.

The front ring is secured on the upper part of the support casing.

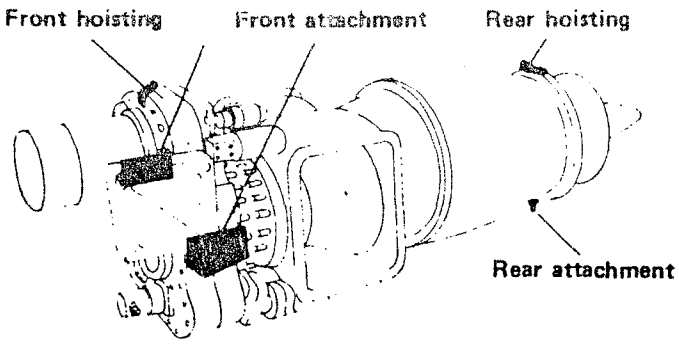
The rear ring is secured on the upper part of the turbine casing rear flange.

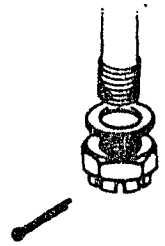
MAINTENANCE

The maintenance procedures belong to the airframe and consequently, they are dealt with in the aircraft manufacturer's manuals.

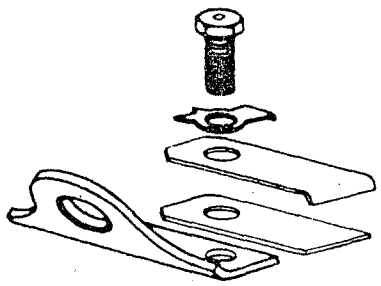
Nevertheless, let us recall that the front attachment must be carefully inspected.

An abnormal clearance in the engine attachment may cause vibrations.

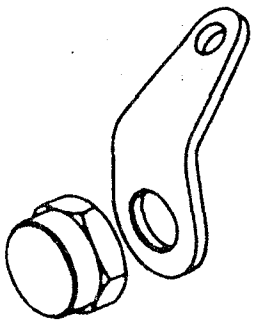




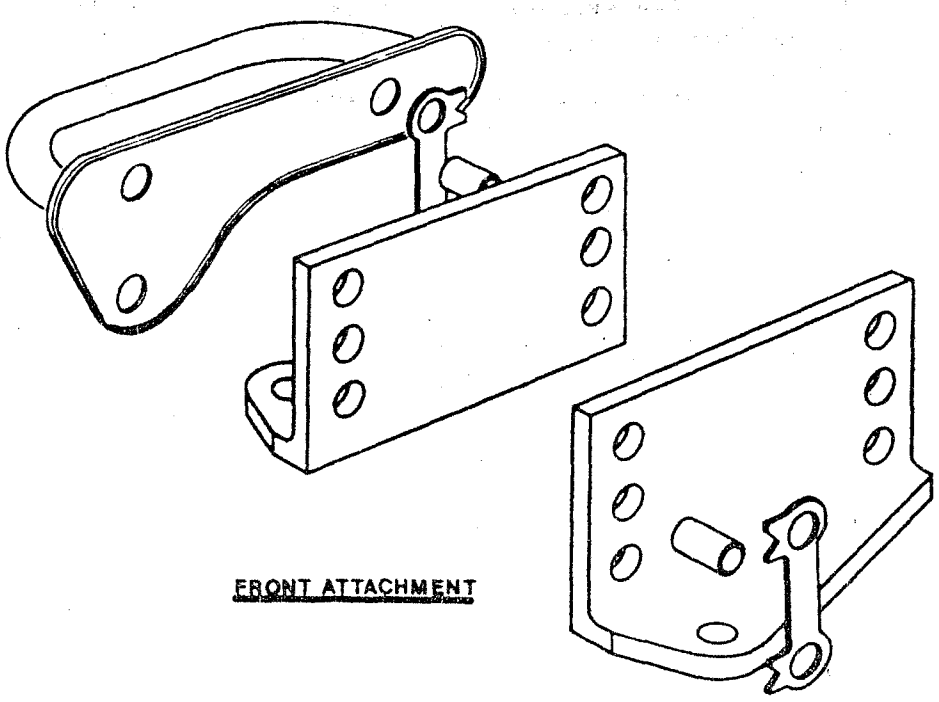
REAR ATTACHMENT



REAR HOISTING



FRONT HOISTING



FRONT ATTACHMENT

ACCESSORY DRIVE

In addition to the various drives used for engine accessories, the accessory drive train incorporates two "spare" drives.

A pinion located on the rear upper surface of the accessory drive which may be used to the rotation speed indication.

The reduction ratio of this drive is N/4.206, and the boss is normally blanked by a bolted cap.

Another spare drive is mounted on the front upper surface of the accessory drive casing.

It may be used (with special agreement with manufacturer) to drive an alternator.

P2 AIR TAPPING

The turbine casing incorporates at its upper part, a boss allowing the installation of a compressed air tapping point.

This tapping point is at aircraft manufacturer's disposal who can use it to various purposes.

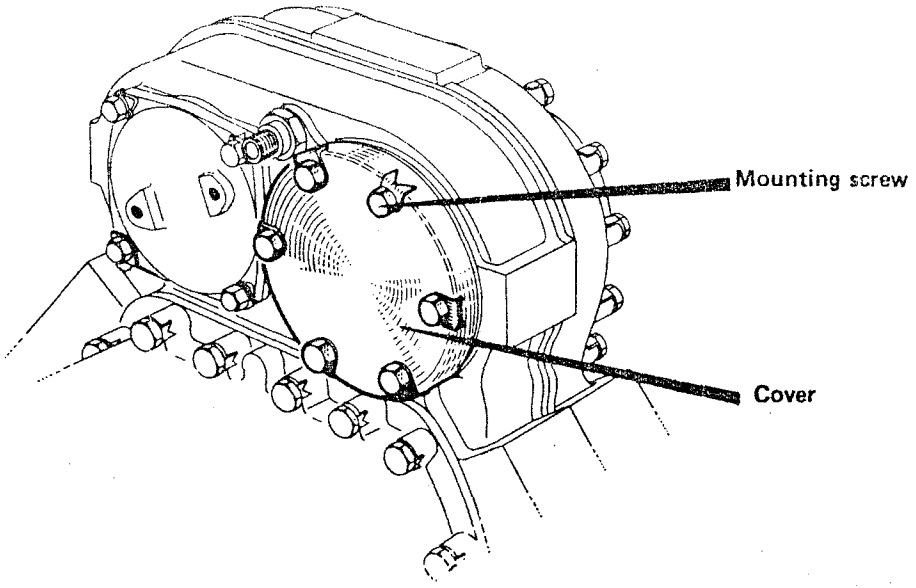
In the case of installation on ALOUETTE III, the compressed air is used for the cockpit heating system.

The characteristics of the air which can be taken at the compressor outlet (P2 air) are the following :

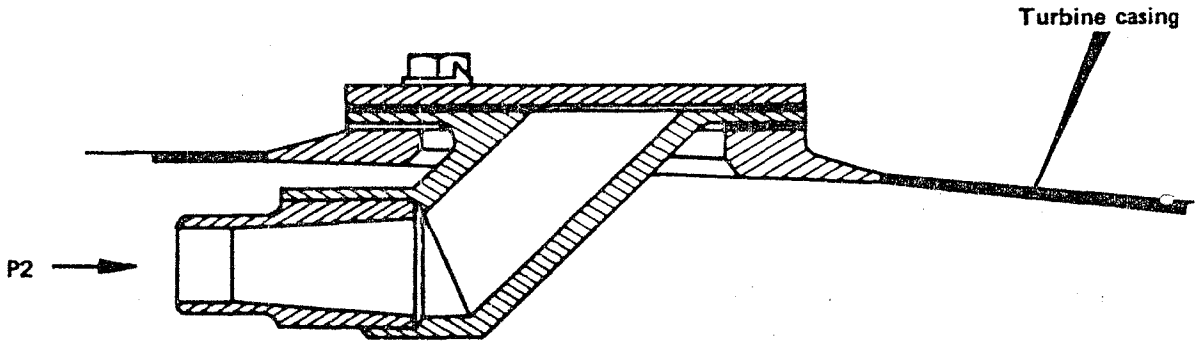
- pressure 5.2
- air flow ..... 80 gr/sec.
- temperature ..... 250° C
- loss of power ..... 0.45 kw/gr/sec.

Note

Any taking of P2 air of course affects the engine performances. Particularly note the effect of air taking on power.



ACCESSORY SPARE DRIVE



P2 AIR TAPPING

ENGINE AIR INTAKE

The two lateral air intakes of engine can be fitted either with guards or with anti-sand filters.

Air intake guards

The purpose of air intake guard is to prevent the ingestion of foreign object during special ground running test.

Blanking plates are also provided for protection when engine is not operated.

Anti-sand filters

When operating in sand loaden atmosphere, it is recommended to install anti-sand filters.

The filters are designed to prevent, as far as possible, the ingestion of sand which leads to the erosion of compressor.

They are provided by the aircraft manufacturer.

JET PIPE

JET PIPE

The exhaust gases are expelled overboard through a short jet pipe mounted on the engine exhaust diffuser.

The jet pipe attachment is ensured by means of a "MARMAN" type collar.

The jet pipe incorporates a heat exchanger used for cockpit heating . The lower part of the jet pipe is provided with a draining point.

Maintenance note

Pay special attention to the tightening torque of the "MARMAN" collar securing bolt.

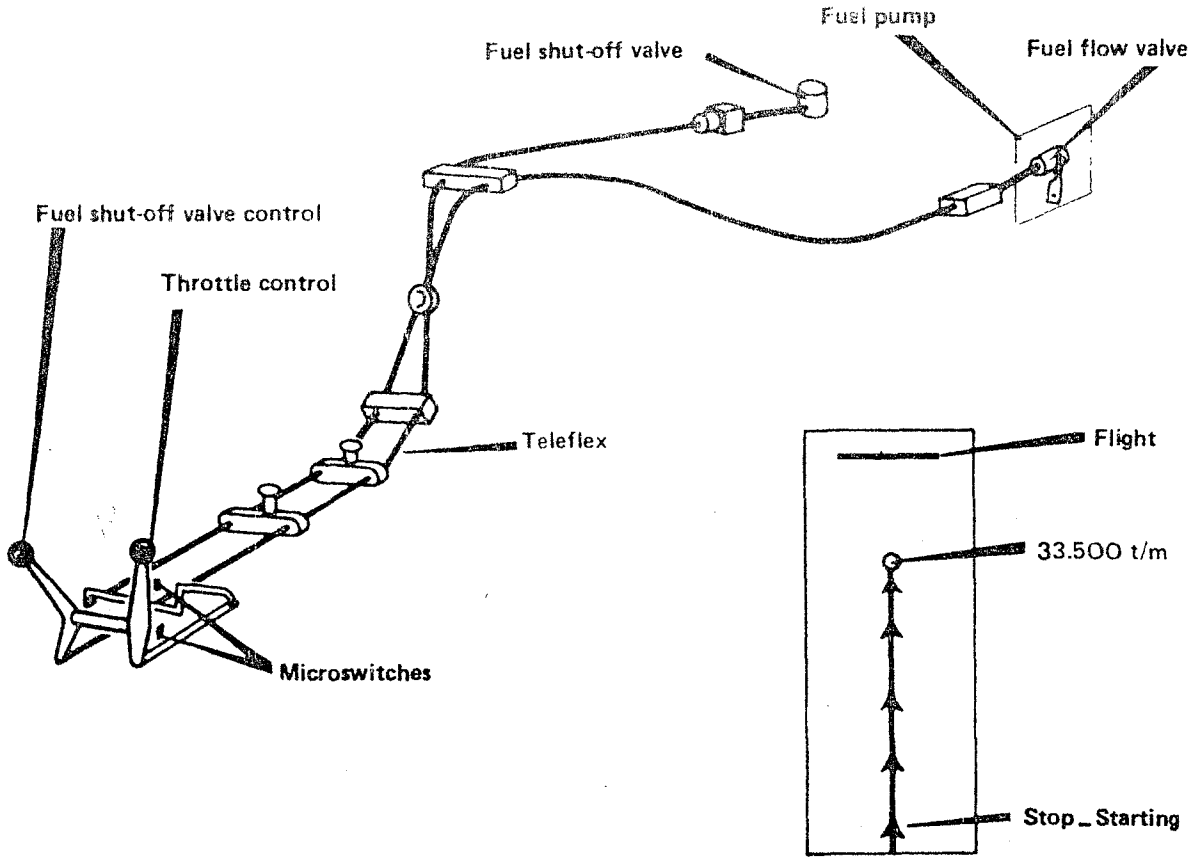
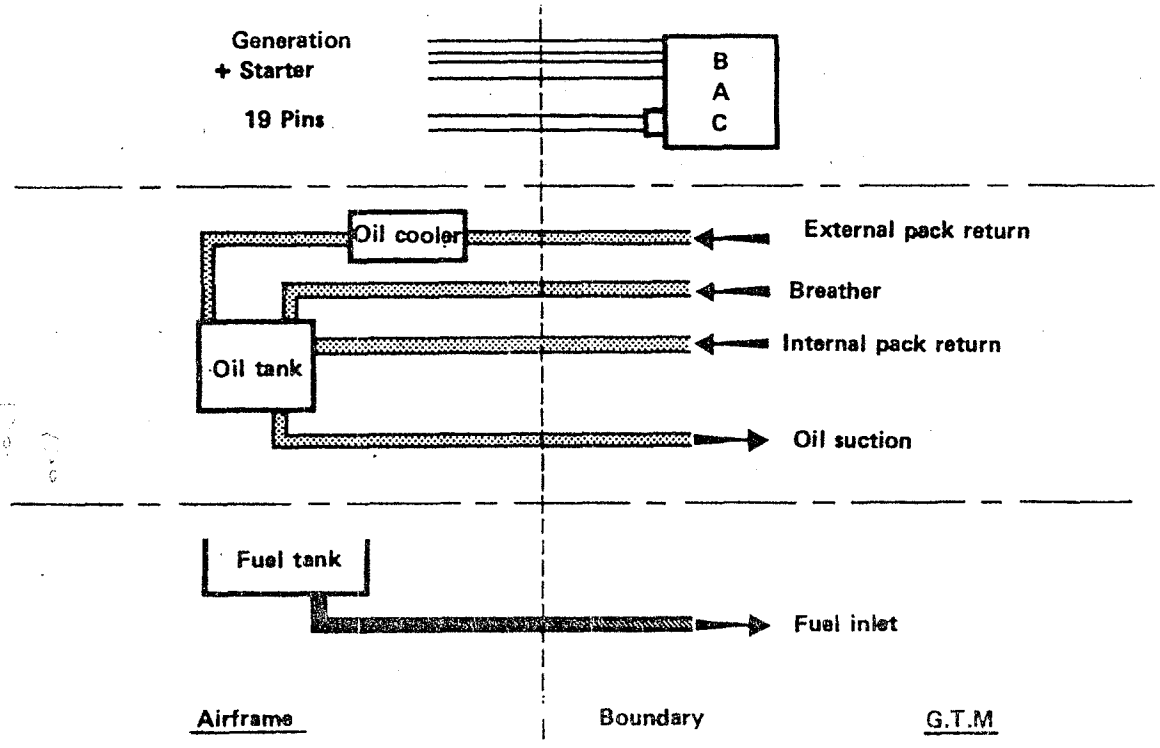
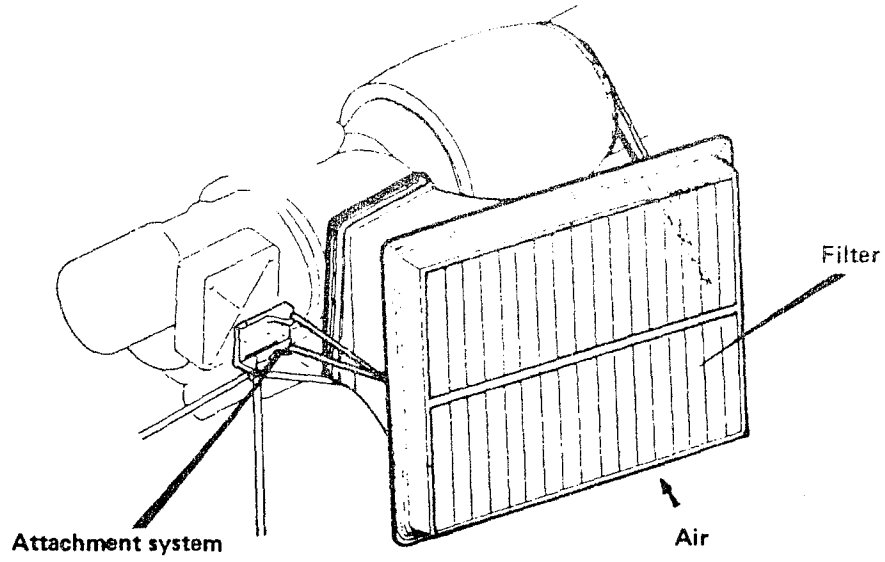


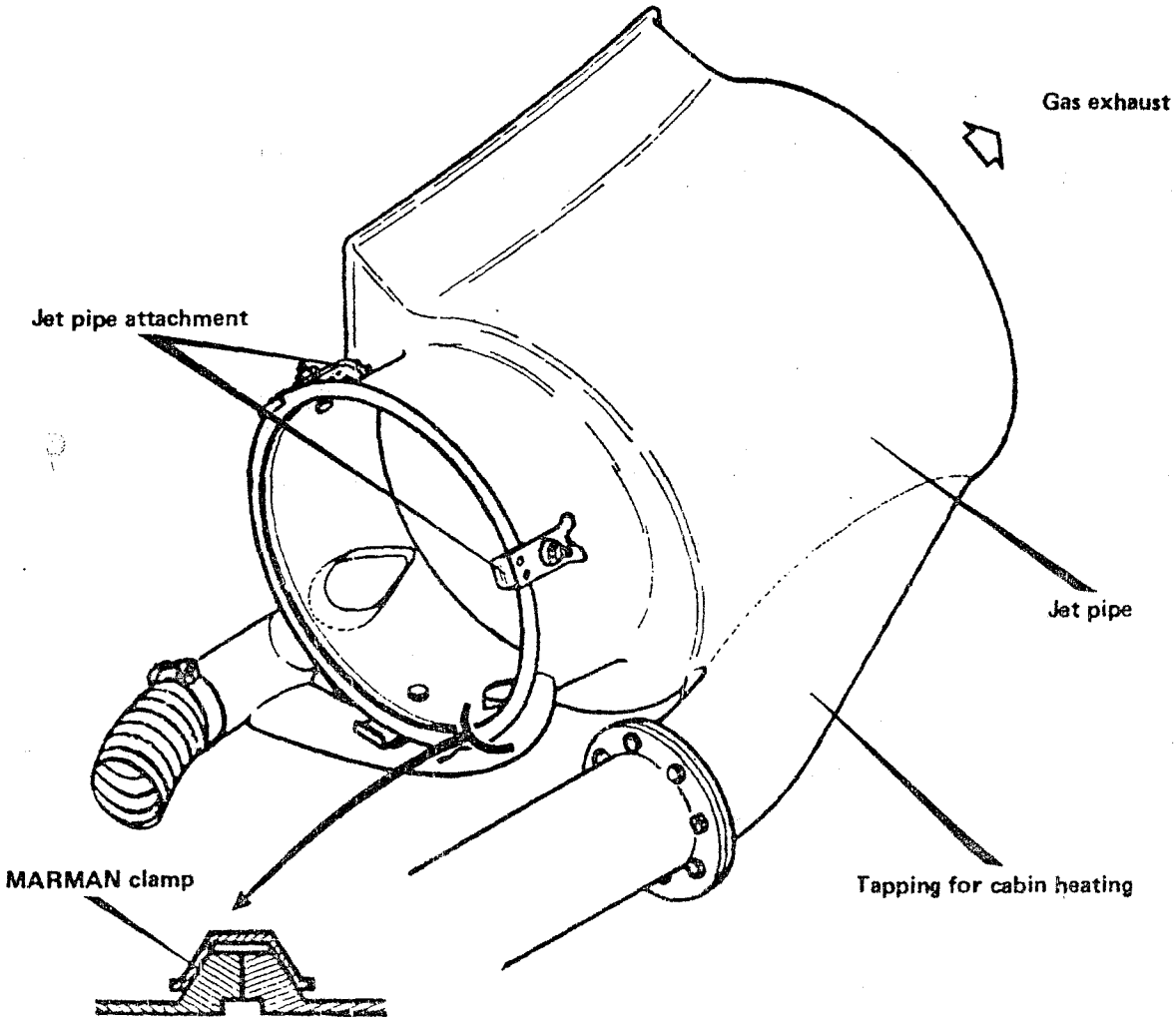
DIAGRAMME OF ENGINE CONTROLS



SCHEMATIC DIAGRAM OF CONNECTIONS



ANTI–SAND FILTER



JET PIPE INSTALLATION

ENGINE CONTROL

The control of the fuel control valve of the fuel pump is carried out by means of a system including :

- the control lever
- the transmission system.

The control lever

The control levers are installed side by side on the helicopter cockpit.

The right hand side lever to control the fuel shut-off valve, the left hand side lever to control the fuel pump throttle valve.

Installation is provided by the aircraft manufacturer.

The transmission system

It includes the control system from the quadrant to the shut-off valve and to fuel pump throttle valve.

It is a teleflex system under the responsability of the aircraft manufacturer.

ENGINE CONNECTIONS

The linking between the engine and the airframe is carried out by means of connecting systems , on may consider :

- electric connections,
- oil system connections,
- fuel system connections.

Electric system

- 19-pin plug connecting the automatic control box to the airframe,
- starter-generator plug.

Oil system

- oil supply from tank,
- return to external set of pumps,
- return to internal set of pumps,
- breathering.

Fuel system

- fuel supply.

NOTES

CHAPTER 11

STARTING

_ INTRODUCTION

_ ENGINE CRANKING

_ IGNITION FUEL SYSTEM

_ IGNITION

_ ENGINE VENTILATION

_ ENGINE STOPPING

_ CONTROL AND INDICATING

_ SEQUENCES OF OPERATION

_ CHARACTERISTICS AND LIMITATIONS

_ OPERATIONS

INTRODUCTION

The "starting" system must carry out the following functions :

ENGINE CRANKING

This function consists in cranking the rotating assembly in order to ensure the supply with air to the combustion chamber.

FUEL SUPPLY

It is the function which consists in supplying with fuel the combustion chamber during engine starting.

IGNITION

The "ignition" function consists in inducing the ignition of the air/fuel mixture in the combustion chamber during the starting initial phase.

VENTILATION

The "ventilation" function consists in cranking the rotating assembly without initiating neither fuel supply nor ignition.

STOPPING

It is the function of fuel shut-off allowing the engine stopping.

CONTROL AND INDICATION OF OPERATION

This function consists in controlling and organizing the various functions and in allowing the indication of operation.

LAY-OUT OF THE CHAPTER

The starting function is dealt with in the following way :

- study of the various functions,
- sequences - general.

Note

Most of accessories involved to carry out this function are also covered in the various chapters (particularly the "control and indication of operation" forms the subject of the chapter "Electric system").

ENGINE CRANKING

INTRODUCTION

The engine cranking (or driving of the rotating assembly) is carried out by means of a starter-generator installed on the front upper part of the accessory drive casing.

As a starter, it drives the rotating assembly, and as a generator, it is driven by the rotating assembly.

DESCRIPTION

The starter-generator is essentially composed of :

- an armature
- a carcase with field magnets
- a collector bearing
- a flange bearing
- a ventilation nozzle.

OPERATION

As a starter, the electric motor is supplied through a relay and an automatic control box. When the engine reaches a certain speed, the supply to the starter is automatically cut-out.

As a generator, it is driven by the accessory train and it delivers an electric power of generation.

MAINTENANCE

Characteristics

- drive speed N/5.108
- rotation direction ..... SH (NFL 30010 norme)
- power as a generator ..... 4,000 watts under 28.5 v
- starter characteristic ..... 400 A under 20 v
- maximum intensity ..... 850 A during 1 sec.
- torque ..... 3 m/kg at 1,400 RPM.

Maintenance

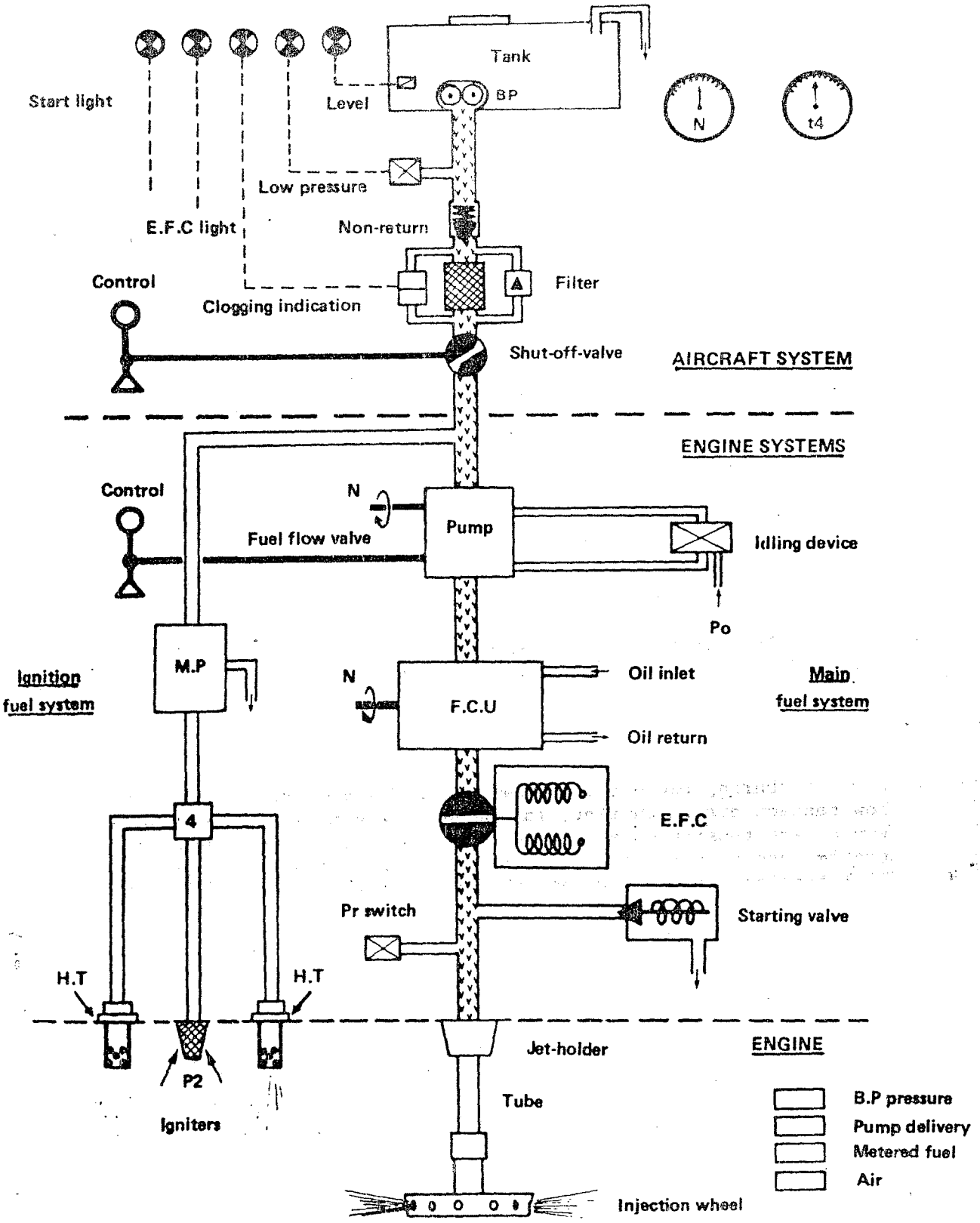
- brushes and collector inspection
- insulation check.

Fault analysis

- see electric system.

Practical works

- locating
- brushes and collector inspection
- insulation check
- shaft seal replacement
- installation and removal.



FUEL SYSTEM BLOCK DIAGRAM

IGNITION

INTRODUCTION

The "ignition" function consists in inducing the ignition of the air/fuel mixture in the combustion chamber during the starting initial phase.

DESCRIPTION

The ignition system incorporates : a dual ignition coil, "igniter" cables and two torch-igniters.

The ignition coil consists of two transformers, each one supplying one igniter. Each transformer includes : a primary winding, a breaker, a secondary winding and a condenser.

The "igniter" cables connect the dual coil to the two torch-igniters.

The torch-igniters receive the high tension current from the coil and generate sparks between the two electrodes.

OPERATION

During the starting initial phase, the coil is supplied with low tension direct current. The primary winding controls the breaker and a high tension current induced in the secondary winding is transmitted to the torch-igniters. The torch-igniters supplied with high tension current generate the spark permitting the fuel ignition.

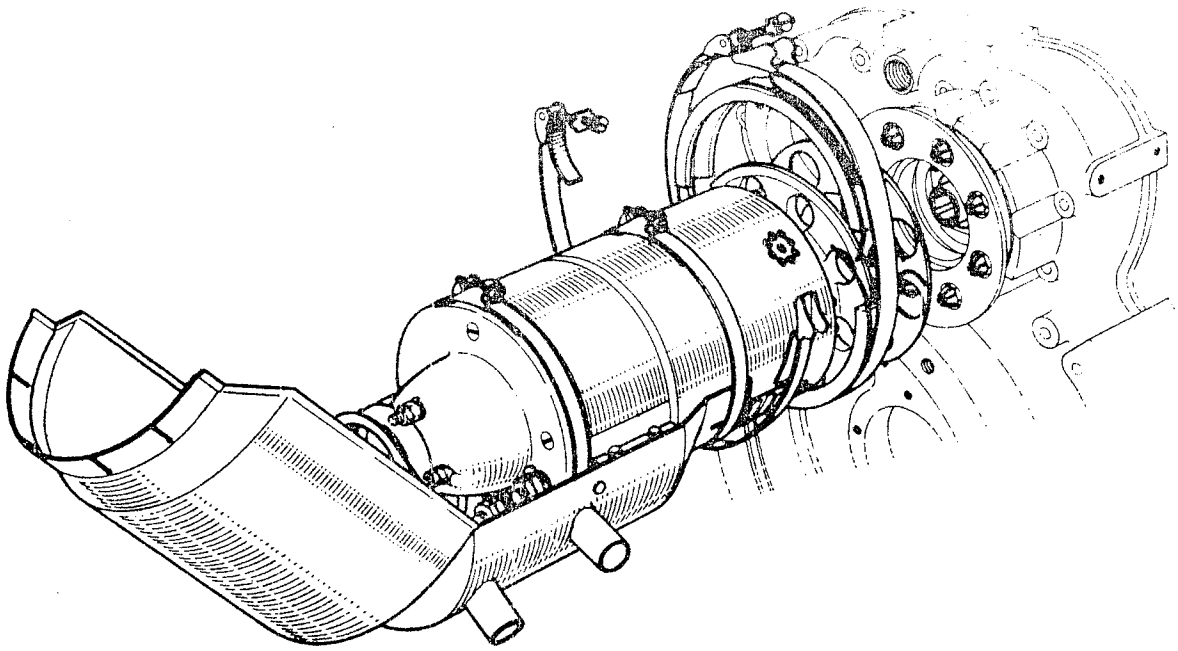
MAINTENANCE

Characteristics

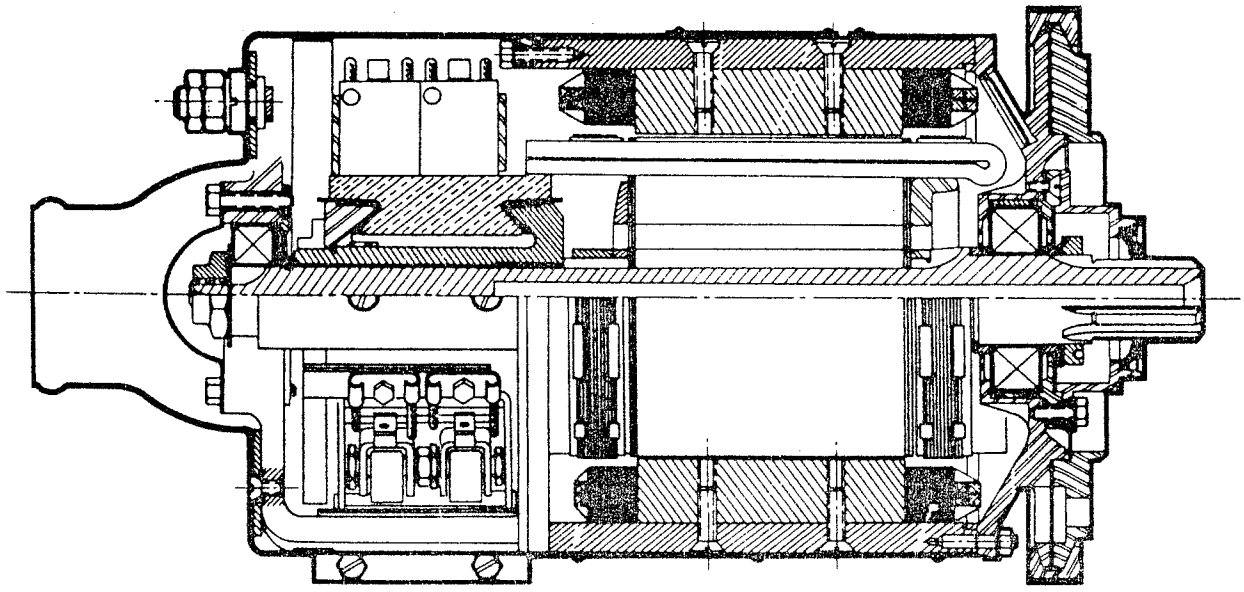
- Supply tension ..... 24 volts
- Outlet tension ..... 15,000 volts
- Intensity ..... about 5 Amp.

Check-out procedure

See procedure in chapter "Maintenance".



SCHEMATIC DIAGRAM OF THE STARTER GENRATOR INSTALLATION



STARTER–GENERATOR CUT AWAY

IGNITION FUEL SYSTEM

INTRODUCTION

It is the function which consists in ensuring the supply with fuel to the combustion chamber during starting.

DESCRIPTION

The fuel supply during starting involves two systems : the ignition fuel system, and the main fuel system.

The ignition fuel system

It incorporates :

- a supply micro-pump
- a distributing four-way union
- two torch-igniters
- a ventilation system for the igniters.

The main fuel system

During starting, it involves :

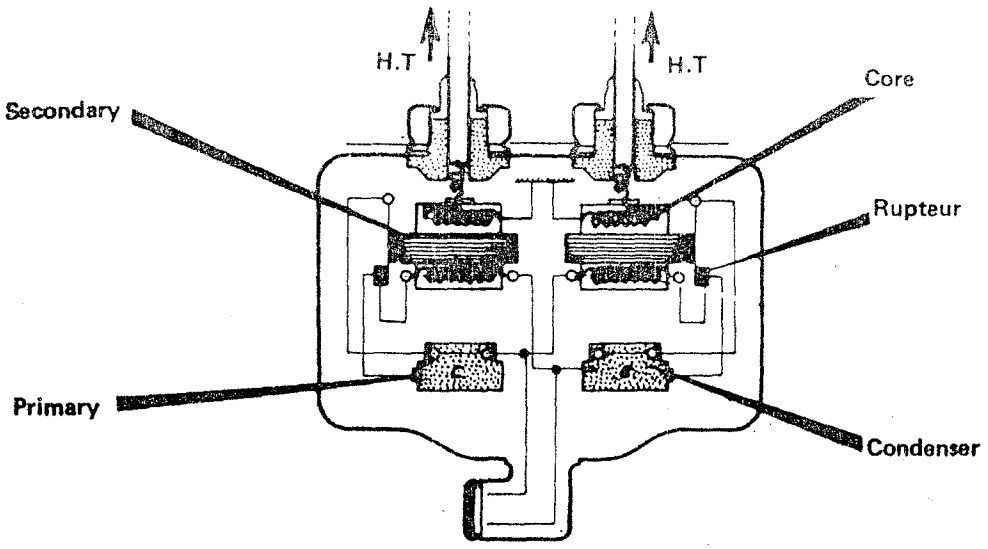
- the main fuel pump
- the idling device
- the electric fuel cock
- the starting fuel valve
- the fuel injection system.

OPERATION

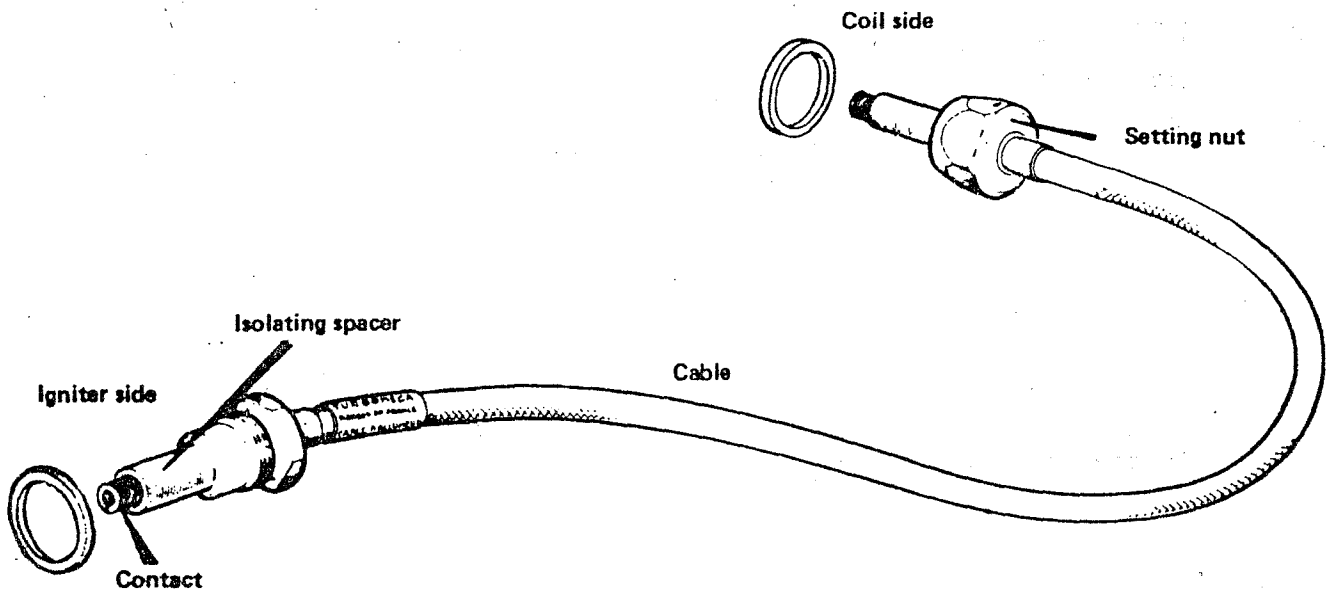
During starting, the operation of all the accessories of the fuel system is automatically controlled. Refer to chapter "Fuel system" and to chapter "Electric system".

MAINTENANCE

See chapter corresponding to each component.



SCHEMATIC DIAGRAM OF THE DUAL IGNITION COIL



IGNITER CABLE

ENGINE VENTILATION

INTRODUCTION

The ventilation function consists in cranking the rotating assembly without introducing ignition. As a matter of fact, it corresponds to the "engine cranking" phase (i.e. "dry" ventilation).

The ventilation is to be carried out :

- after a de-inhibiting, a faulty starting or an accidental flame-out in order to drain out the fuel accumulated in the combustion chamber.

- before carrying out a start when the residual temperature of the gases is too high.

- for various checks (detect an abnormal noise for instance).

DESCRIPTION OF THE SYSTEM

The ventilation system involves the accessories of the rotating assembly cranking, that is :

- the starter-generator
- the starter cut-out switch
- the control and indication automatic circuit.

OPERATION

The ventilation function is carried out by placing the start switch in the position "ventilate" and by holding it in this position (a release spring tends to bring the switch back to "stop").

When the ventilation is selected, the starting green light goes "on" and the engine begins running ; the speed becomes stable at about 5,000 RPM.

To stop the ventilation, it is merely necessary to release the switch which is then automatically brought back to "stop".

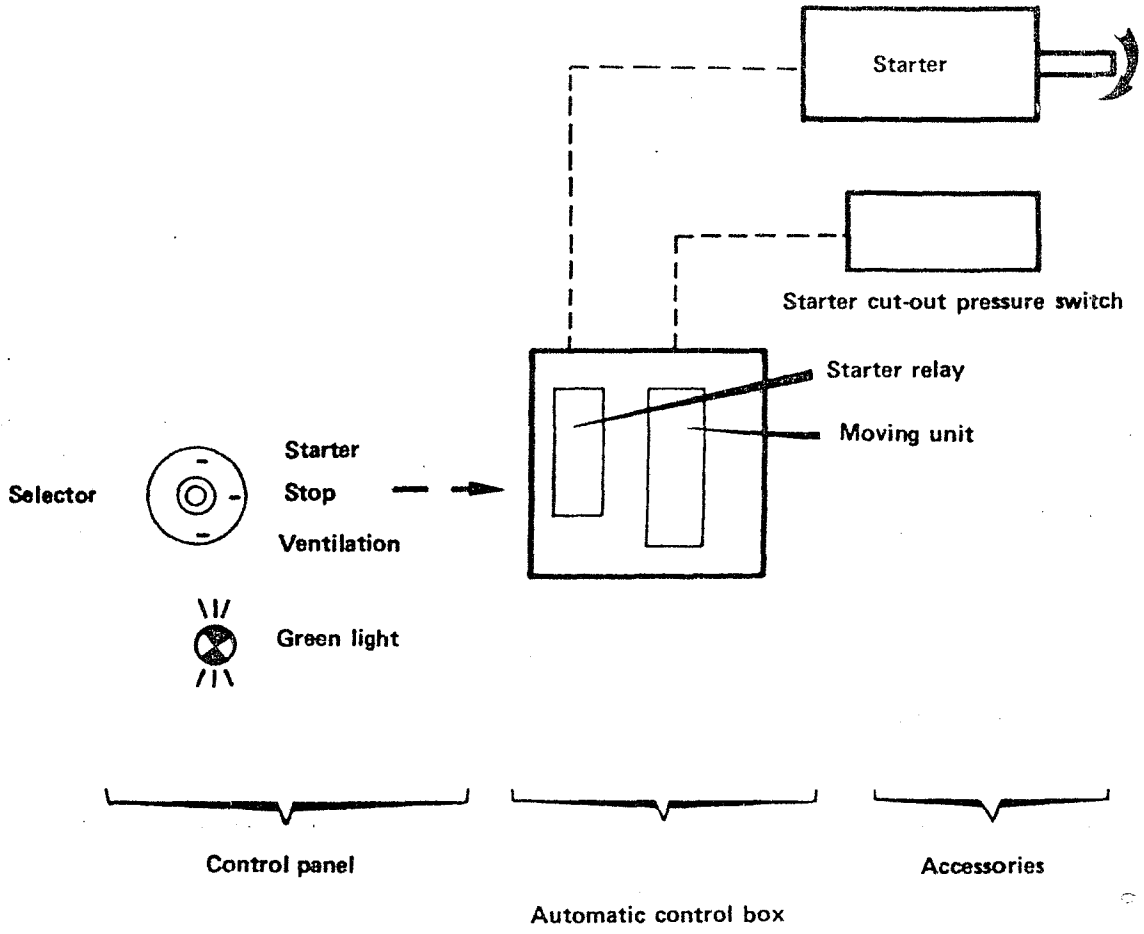
Note

It is recommended not to carry out a ventilation during more than 15 seconds, and to let the starter-generator cool down before initiating another ventilation or a start.

If the operator holds the switch on "ventilate" during more than 50 seconds, a time-delay switch stops the ventilation phase automatically. The blockage red light goes "on" at the end of this sequence.

Note

Detailed operation and maintenance are considered in the chapter "Electric system".



VENTILATION SEQUENCE DIAGRAM

ENGINE STOPPING

INTRODUCTION

This function consists essentially in ensuring the fuel shut-off for engine stopping.

DESCRIPTION

The "stop" function involves the operation of components which are also used during the starting phase.

The fuel shut-off is carried out by means of the electric fuel cock located in the main fuel system.

OPERATION

The engine stopping (normal stopping) must be controlled only after rotation speed deceleration by the fuel control lever. A safety device prevents stopping when the lever is opened.

The "stop" selection is carried out by placing the switch "start-stop-ventilate" to position "stop".

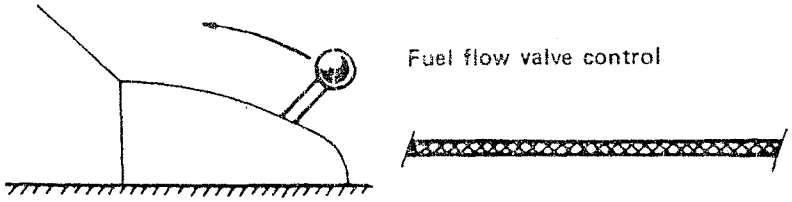
The "stop" switching causes, by means of the electric system, the electric fuel cock closing and consequently the engine stopping.

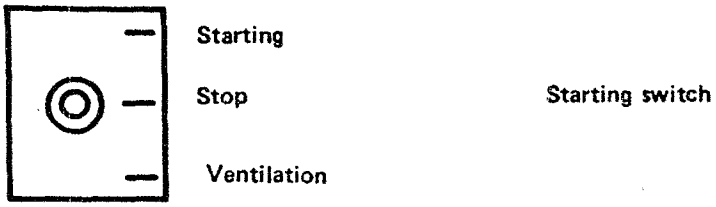
The fuel cock yellow light goes "on" a very short moment and thus indicates the fuel cock closing.

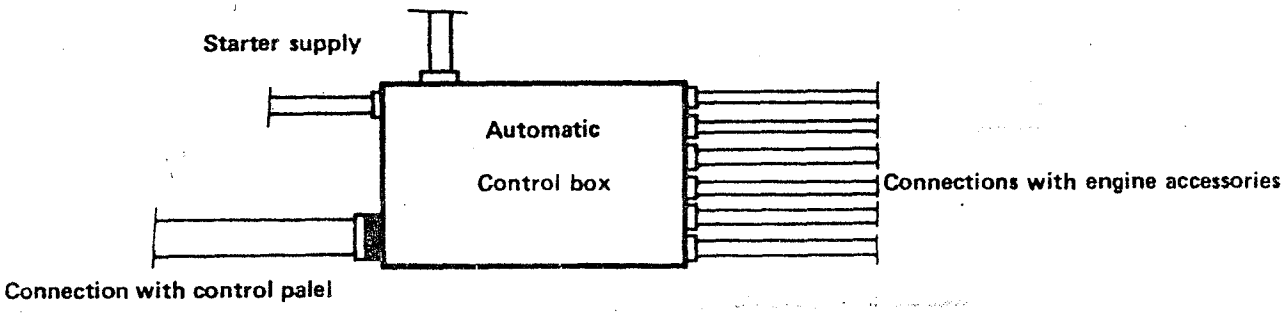
Immediately after, the red blockage light goes "on" and remains "on" during a score of seconds, thus indicating the "resetting" phase of the electric system.

The engine complete stopping requires a certain time which gives an interesting indication about the free rotation of the rotating assembly. This time called "run-down time" is included between the moment when the switch is set to "stop" and the moment of complete immobilization of the rotating assembly. It must exceed a duration of about 45 seconds.

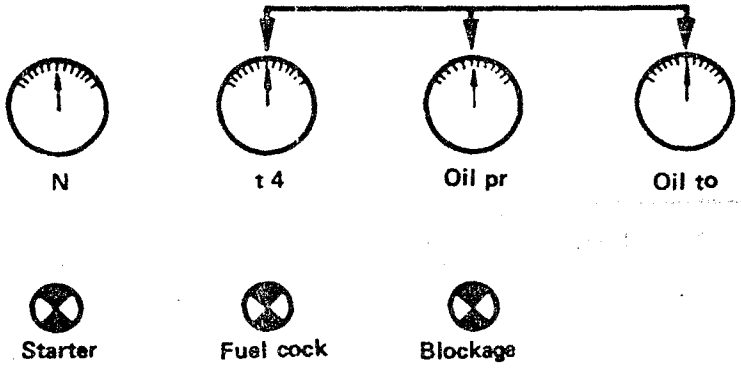
Nevertheless, the run-down time is affected by numerous parameters such as : idling speed, temperature, oil viscosity, accessory "friction" ...







CONTROL UNITS



ENGINE INSTRUMENTATION

SEQUENCES OF OPERATION

INTRODUCTION

The sequences of operation are manually and automatically controlled in a well determined order. In a schematic way, it is possible to consider :

STARTING

Manual sequence

- Power on the electric system
- Switch to "start"

Automatic sequence

- Micro-pump microswitch action
- Fuel cock opening and tripping of the contacts
- T5A time-delay switch action
- Starter cut-out switch action.

STOPPING

Manual sequence

- Switch to "stop"

Automatic sequence

- Fuel cock closing and tripping of the contacts
- T5R time-delay switch action.

VENTILATION

Manual sequence

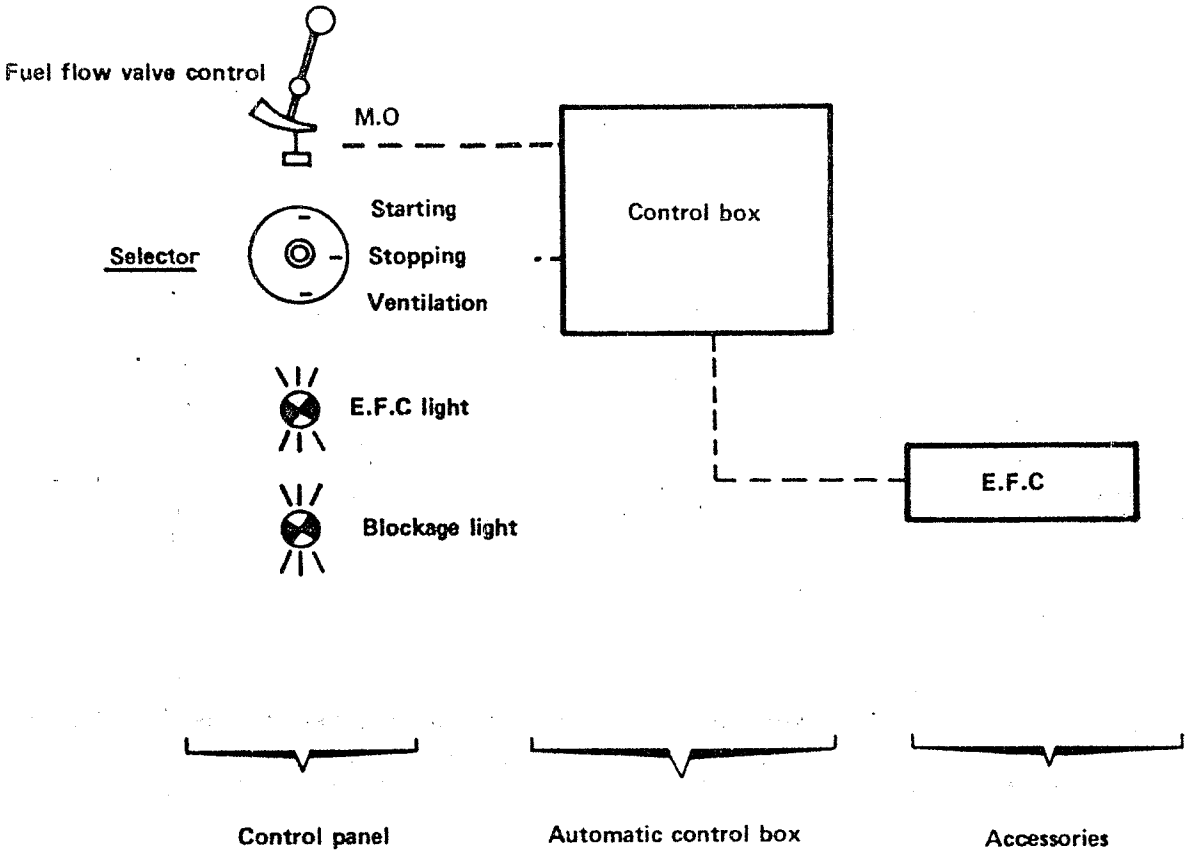
- Power on the system
- Switch to "ventilate".

Automatic sequence

- T30 time-delay switch action.

Note

All these sequences of operation are dealt with in detail in the chapter "Electric system".



ENGINE STOPPING SEQUENCE DIAGRAM

CONTROL AND INDICATING

INTRODUCTION

The various functions of the starting system must be carried out according to a series of operations in an order and a time which are determined. These various operations involve some "control" components and "indicating" components.

CONTROL OF THE STARTING SYSTEM

The starting system involves "manual control components" and "automatic control components".

Manual control components

They are :

- the fuel control valve control lever,
- the switches and circuit-breakers to set electric power on the system,
- the booster-pump switch,
- the "start-stop-ventilate" switch.

Automatic control components

It is essentially the automatic control box which determines the various sequences.

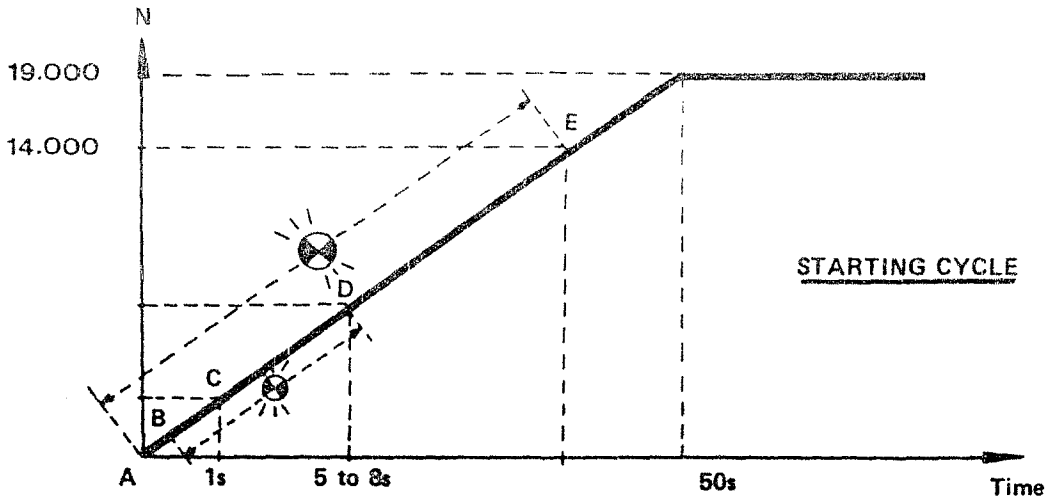
The automatic control box is mounted on the engine left side by means of two brackets and it is connected by wirings to engine accessories on one side, and to the aircraft systems on the other side.

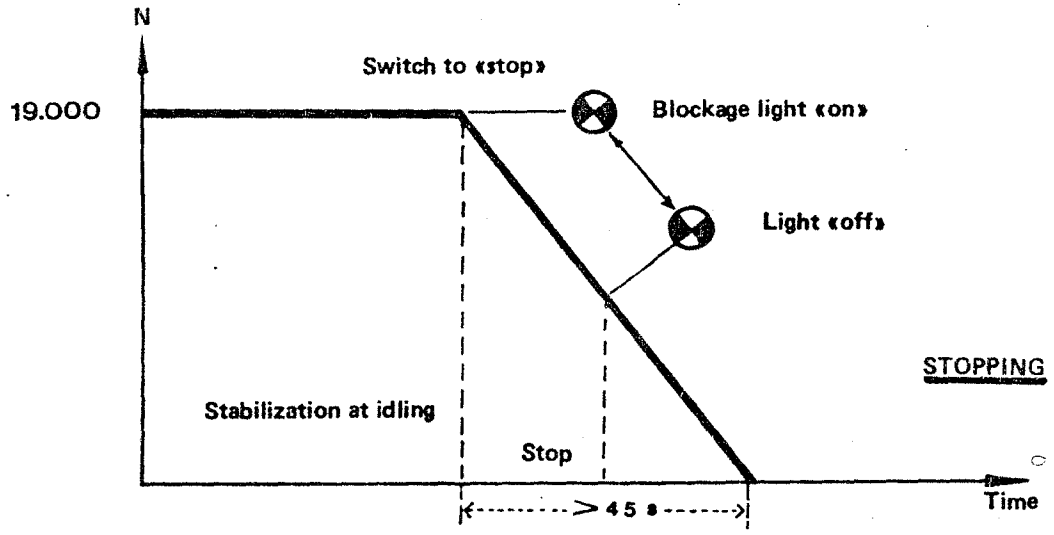
The box incorporates the starter switch (or starter relay) , connecting bars, and a moving control unit. The moving unit includes all the components required to control the automatic sequences.

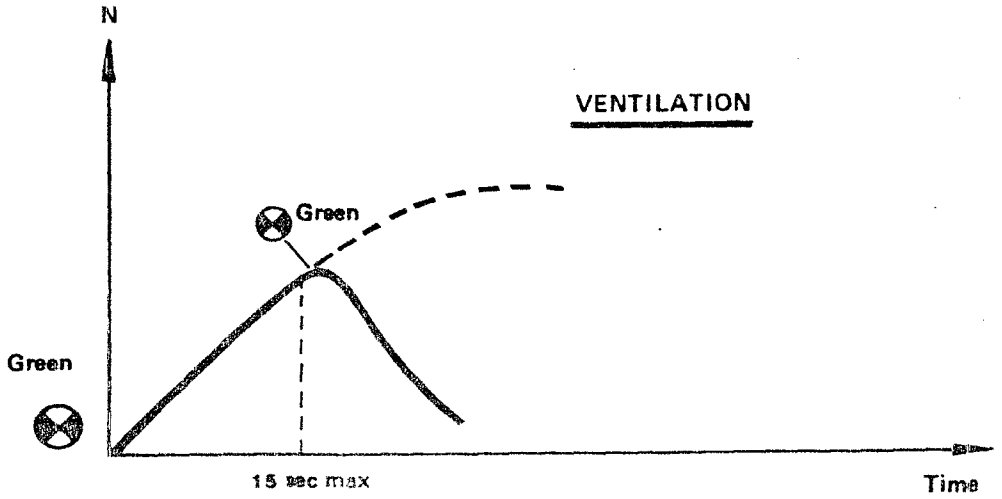
INDICATING OF THE STARTING SYSTEM

The indication is carried out by means of :

- the rotation speed indicating system
- the t4 gas temperature indicating system
- the oil pressure and temperature indicating system
- the indicating lights. Essentially :
  - starting green light
  - fuel cock yellow light
  - blockage red light.


N
19.000
14.000
E
D
C
B
A
1s
5 to 8s
50s
Time
STARTING CYCLE


N
19.000
Switch to «stop»
Blockage light «on»
Light «off»
STOPPING
Stabilization at idling
Stop
> 45 s
Time


N
VENTILATION
Green
Green
15 sec max
Time

CHARACTERISTICS AND LIMITATIONS

TIMES

- Starting max. time ..... 50 s
- Ignition time ..... 6 to 15 s
- Time for micro-pump pressure building-up ..... 1/2 s
- Fuel cock opening (or closing) time ..... 3/4 s
- Resetting time during stopping ..... 17 to 20 s
- Ventilation time ..... 15 s (max 50s)
- Waiting time between 2 false starts ..... 3 minutes
- Waiting time after 3 consecutive false starts. 20 minutes
- Run-down time during stopping ..... > to 45 s

ROTATION SPEEDS

- Starter cut-out speed ..... 14,000 $\pm$ 1000 RPM
- Idling speed ..... 18,500 $\pm$ 1000 RPM
- Clutching speed ..... About 22,000 RPM
- Speed at MO action ..... 26,800 RPM

TEMPERATURES

- Max. residual t4 ..... 150° C
- Max. t4 at starting ..... 600° C (630°max)
- t4 during acceleration..... Δ t4 < to 50° C

OIL

- Pressure at idling speed ..... > to 0,8 b
- Min. temperature (before applying W)..... > to 10°C

ELECTRIC SYSTEM

- Min. static tension of battery ..... 25 V
- Max. voltage drop during starting ..... V must stay > 14V

OPERATIONS

STARTING

a) Check residual t4 (must be lower than 150° C)

b) Booster pump "on" (light "out", micro-pump draining)

c) Start switch to "start"

- Chrono
- Green light check
- Yellow light check (goes "on" after 1/2 sec.)
- Oil pressure check
- t4 check (lower than 60° C)
- Yellow light check (must go "out" after 8 to 10 sec.)
- Green light check (must go "out" at 14,000 RPM)
- Time check (14,000 RPM in less than 45 sec.)
- Idling check (15,000 to 19,000 RPM)
- Oil pressure and temperature check.

d) Acceleration (lever displacement)

- Clutching check
- t4, N and light check.

ENGINE STOPPING

a) Deceleration and idling stabilization

b) Switch to "stop".

- Yellow light check (flash)
- Blockage light check ("on")
- Stop check (N, t4 and time)
- Blockage light check ("out")
- General cut-out.

VENTILATION

a) Prior procedure and switch to "ventilate"

- N and starting light check

b) Ventilation stop (switch brought back to "stop")

- Ventilation must not exceed 15 sec.

NOTES

CHAPTER 12

ELECTRIC SYSTEM

_ GENERAL

- Symbols
- Review
- Operation of relays
- Operation of time delay switch
- Electric systems representations

_ DESCRIPTION OF THE SYSTEM

- Introduction
- Components identification

_ OPERATION OF THE SYSTEM

- Introduction
- Sequences of operation

_ MAINTENANCE

- Characteristics
- Operating instructions and servicing
- Checks and adjustments
- Fault analysis
- Practical work

GENERAL

SYMBOLS

Negative polarity


Positive polarity


Direct current


Alternating current


Earth

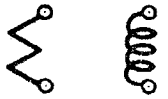

Negative polarity

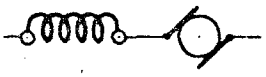

Cross-wiring without junction


Junction

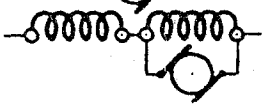

Heating resistor


Voltage drop resistor


Coil


Electric motor (type series)


Electric motor (type shunt)


Electric motor (type compound).


Indicating light (lamp)

Diode (the current can circulate only in the direction of the arrow)

Resting contact

Moving contact

Working contact

For a relay, the moving contact is in position called "working" when the relay is supplied (relay energized).

It is in contact position called "resting" when the relay is not supplied (relay de-energized).

For a microswitch, the contact is called "working" when the microswitch is mechanically actuated.

The microswitch is called "resting" when there is no mechanical action exerted on its plunger.

Note
A circuit can be established by a resting contact as well as by a working contact.

ABBREVIATIONS

R	Electric fuel cock
MP	Micro-pump
MPO	Lever fully opened
MO	Lever opened
MF	Lever closed
BP	Booster pump (BP = Low pressure = Booster pump)
T	Time-delay switch
R	Resistor
D	Diode

REVIEW

Let us recall very briefly the main electric characteristics of a system :

I - Intensity

U - Difference of potential

R - Resistance

and the law of relation of these three characteristics (Ohm law) :

$$U = R\,I$$

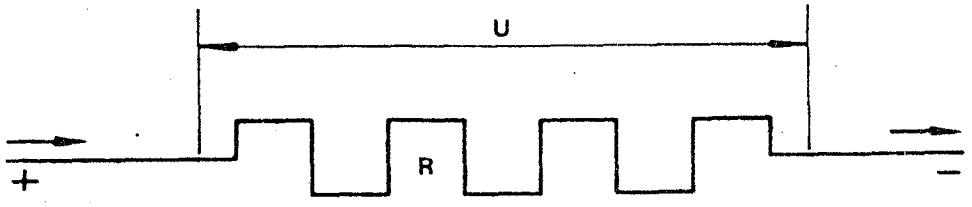
Let us consider a system composed of a supply source (positive), of a resistance R and of an earthing (negative).

The polarities + and - have been conventionaly chosen in order to determine a direction of circulation of the current I in the resistance R.

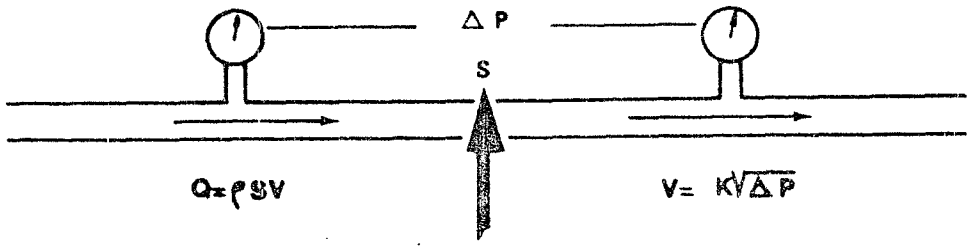
The value of the current determines the value of the difference of potential at the terminals of the resistance.

Hydraulic analogy

The value of the current I determines a difference of potential of the resistance R in the same way as the flow Q (in fluid mechanic) determines the value of the difference of pressure at upstream and downstream of a fixed metering valve R.



U=RI



OPERATION OF A RELAY

An electromagnetic relay is essentially composed of a coil wounded around a soft iron core and of one or several contacts with return spring.

When the coil is electrically supplied, the magnetic forces induced ensure the relay "energizing". The moving contact then reverses its position and sets the contact with the "working" point. The contact is commonly said "going into work".

When the electric supply to the coil is cut-out, the relay is de-energized and the return spring brings the moving contact back against the "resting" point.

It is thus possible to set circuits between the moving contact and the "working" or "resting" contacts according to the position of the relay.

OPERATION OF A RELAY WITH A "SHUNT" CIRCUIT

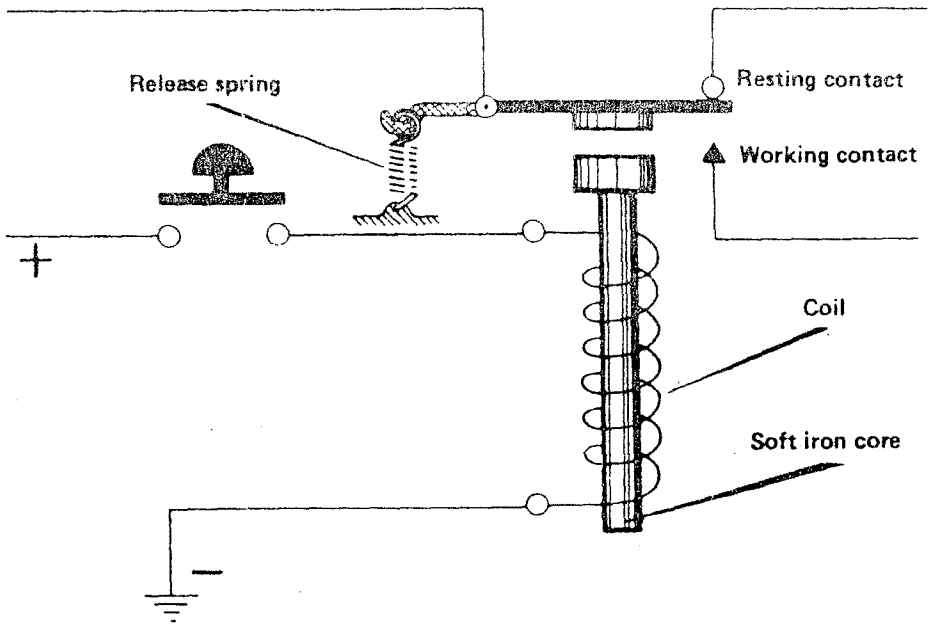
In this type of circuit, the earthing of the coil is made through a so-called "voltage drop" resistance.

The operation is the same as that of a normal relay, but it is possible to initiate the "de-energizing" of the relay without cutting-out the normal supply.

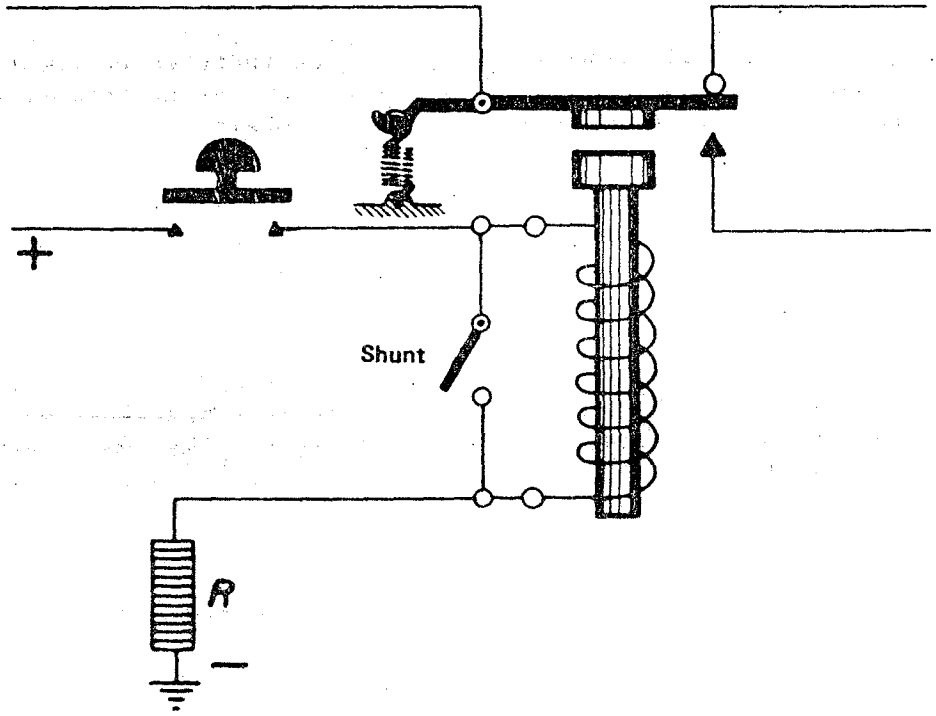
The de-energizing of the relay can be made by means of setting up of a circuit in parallel on the coil.

When the circuit in parallel on the coil is established, the same polarity is found on each side of the coil. There is then no longer potential difference and therefore no more magnetic forces. The relay is "de-energized" and the contact comes back to resting position under the action of the return spring.

The circuit in parallel of the coil is called "shunt circuit".



SCHEMATIC DIAGRAM OF A RELAY



RELAY WITH A SHUNT CIRCUIT

OPERATION OF A TIME-DELAY SWITCH

Bimetal time-delay switch of T5 type

The device consists of a resistance wounded around a bimetal strip and of a plunger which controls a microswitch.

When the resistance is electrically supplied, it heats the bimetal. The bimetal is distorted and after a determined time, comes and actuate the microswitch. The microswitch is then time-delayed controlled.

When the supply is cut-out, the bimetal strip cools down and comes back to its initial position.

Bimetal time-delay switch of T30 type

This type of time-delay switch is composed of two bimetal strips. A main bimetal provided with a resistance and a bimetal without winding called "compensating".

Moreover, an electric circuit is established between the two bimetals which are set in contact by means of an adjustable screw.

It is worthy of note that there is no electrical connection between the heating circuit of the resistance and the circuit established between the two bimetals.

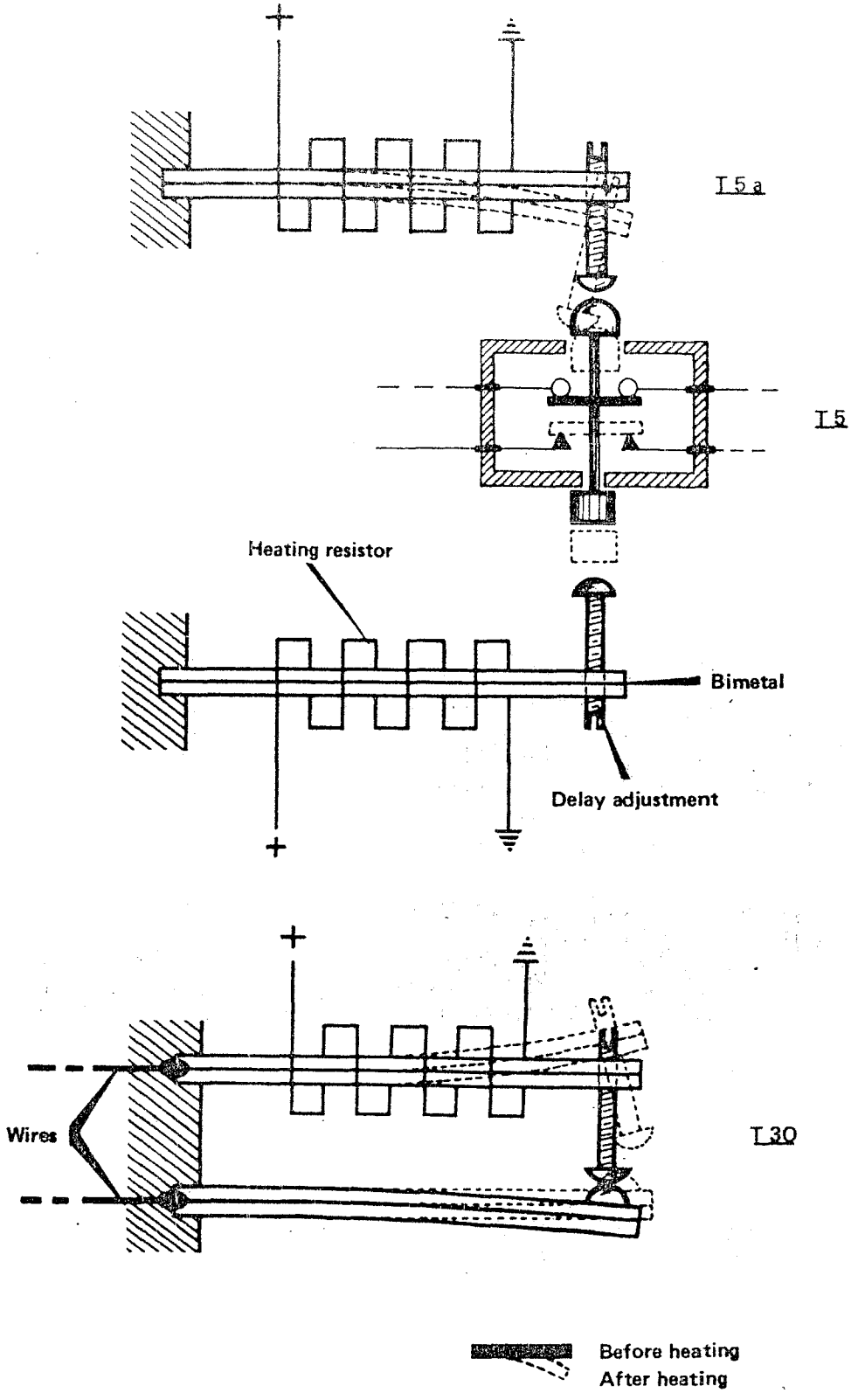
When the resistance is electrically supplied, it heats the bimetal strip around which it is wounded. The bimetal strip is distorted and after a specified time, it cuts out the circuit between the two bimetals.

The bimetal which is not provided with a winding is only distorted in function of the ambient temperature and thus compensates the variations of timing due to the changes in ambient temperature.

Note

The time-delay switch is generally provided with a screw permitting the adjustment of the operating time (timing adjustment).

The check of timing must be carried out under constant supply tension and determined ambient temperature.



HEATING RESISTOR

REPRESENTATION OF THE ELECTRIC CIRCUITS

Two types of representation of the electric circuits are to be considered :

- the representation by schematic diagram
- the representation by "developed" diagram.

Representation by schematic diagram

In this type of diagram, the components of the circuit are represented according to the actual lay-out.

Note

The contacts of the relays are numbered 1, 2, 3 ... ; the contact nr 1 being the nearest of the coil.

Representation by developed diagram

In this type of diagram, the various components of the circuit are represented according to the interest of the circuit and not according to the actual lay-out.

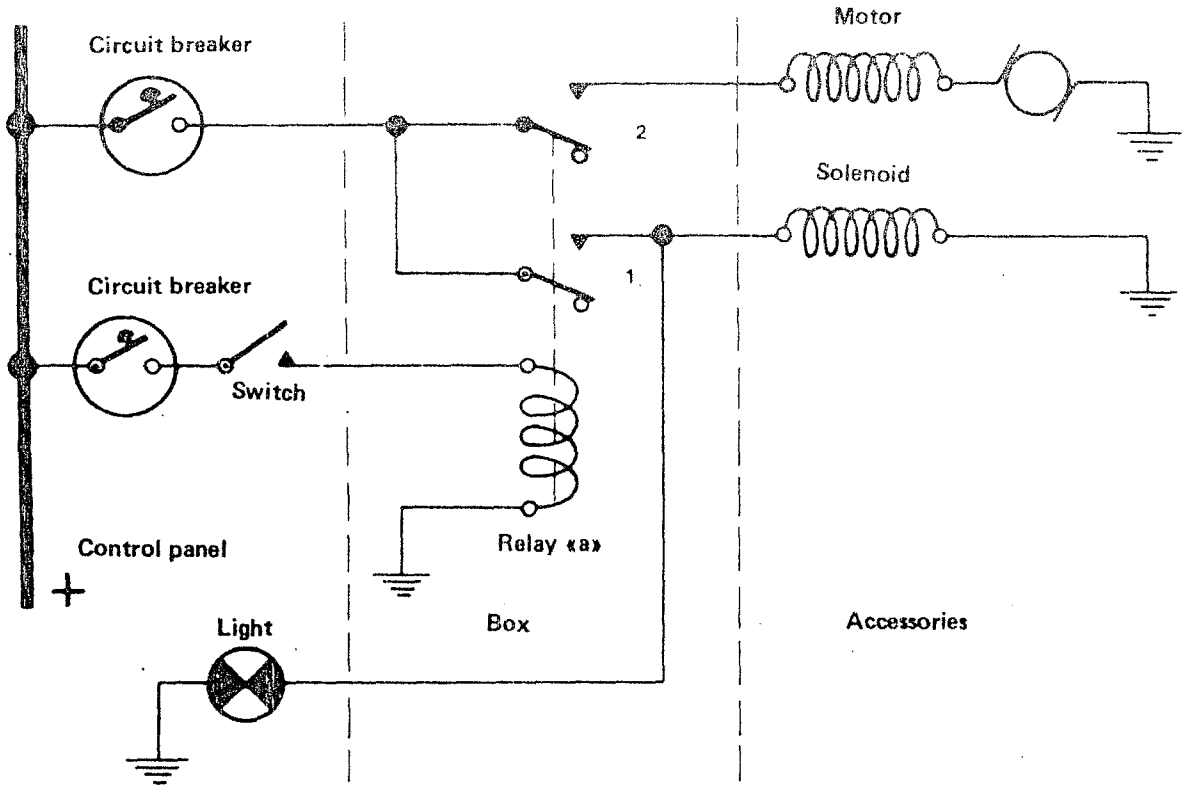
Thus the contacts of the relays are not represented according to their actual geographic location. The coil of the relay can be found in one part of the diagram and the contacts of this relay in another part. It is nevertheless easy to identify them being given that they are represented with the symbol of the relay and the number of the contact.

As a general rule, the circuits must be followed according to a "line" (from top to bottom of the diagram for instance).

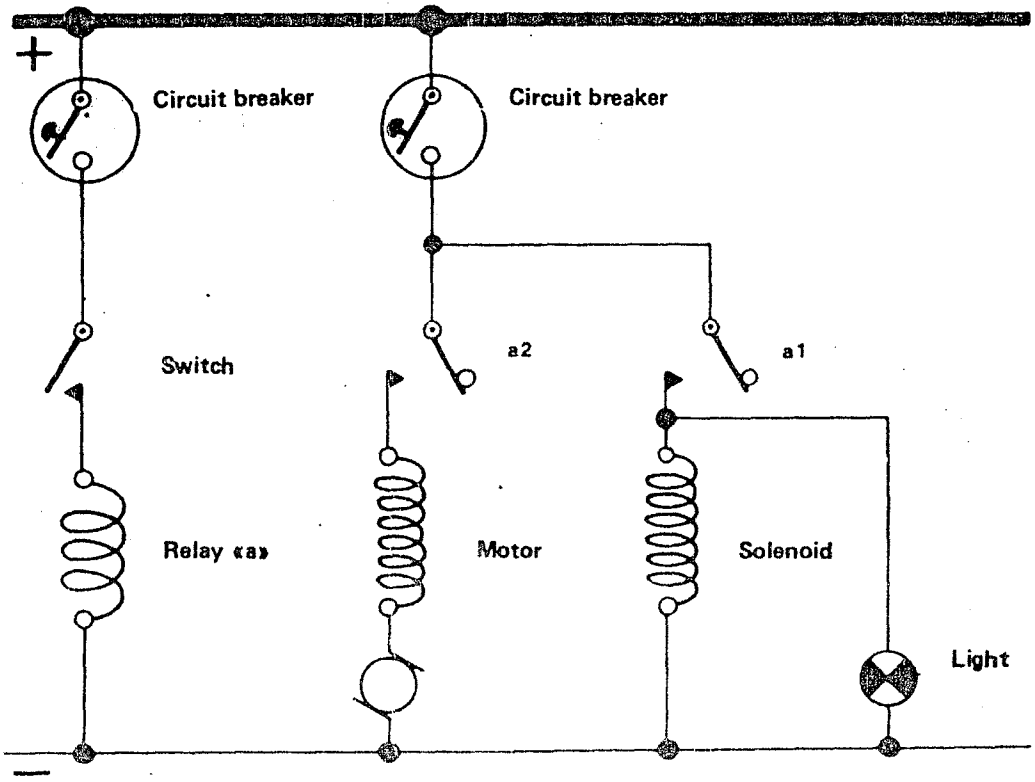
Note

The page attached illustrates the same electric circuit represented in two different ways.

Unless special mention, an electric circuit is always represented without power on the system and in a well determined position.



SCHEMATIC DIAGRAM OF A SYSTEM (Representation of principle)



SCHEMATIC DIAGRAM OF A SYSTEM (Representation «developed»)

DESCRIPTION OF THE SYSTEM

INTRODUCTION

The components of the system are identified by the standard symbols and by a name indicating the function.

The contacts of the relays are numbered 1, 2, 3 ; the contact nr 1 being the nearest of the coil. They are identified by the symbol of the relay followed by the number of the contact. The letter "r" indicates the resting contact and the letter "t" the working contact.

Thus "m2t" means the working contact nr 2 of the relay "m".

The microswitches are considered at rest when they are released i.e. when none mechanical action is exerted on their plunger. They are considered at work when they are mechanically actuated.

As a general rule, the diagrams represent the systems in the following configuration :

- engine stopped
- flow control lever "closed"
- switches to "stop"
- no power on the system.

The diagrams illustrating the various phases of operation are nevertheless represented in the configuration corresponding to the sequence.

The electric system involves components which belong to the aircraft manufacturer as also components which belong to the engine designer. For the components which belong to the aircraft manufacturer, the following description will be restricted in quoting the function and the position. For the components which belong to the engine designer, the description is made in a detailed way in the various chapters.

The description permits the identification of the following groups :

- Microswitches
- Control switches
- Indicating lights
- Engine accessories
- Automatic control box.

MICROSWITCHES

MF (lever closed)

Prevents starting if the lever is not in start position.

The microswitch is at work at 0° of the lever (i.e. lever fully closed).

MO (lever opened)

Prevents engine normal stopping when the lever is opened.

The microswitch changes over at about 2/3 of the lever range.

MPO (lever fully opened)

Indicates the position of lever full opening. Changes over at the end of lever range.

CONTROL SWITCHES

Starter switch

It permits to control "stop", "start" and "ventilation" sequences.

The position "ventilate" is provided with a release spring to "stop" position.

Booster pump switch

Ensures the operation of the booster pump. It incorporates a position "on" and a position "automatic".

Components meant to apply power on the system

They belong to the aircraft manufacturer. Power applying is ensured by a battery contact and circuit-breakers.

INDICATING LIGHTS

Starter light (green)

This light indicates the starting cycle. It is "on" up to about 14,000 RPM during starting.

Fuel cock light (yellow)

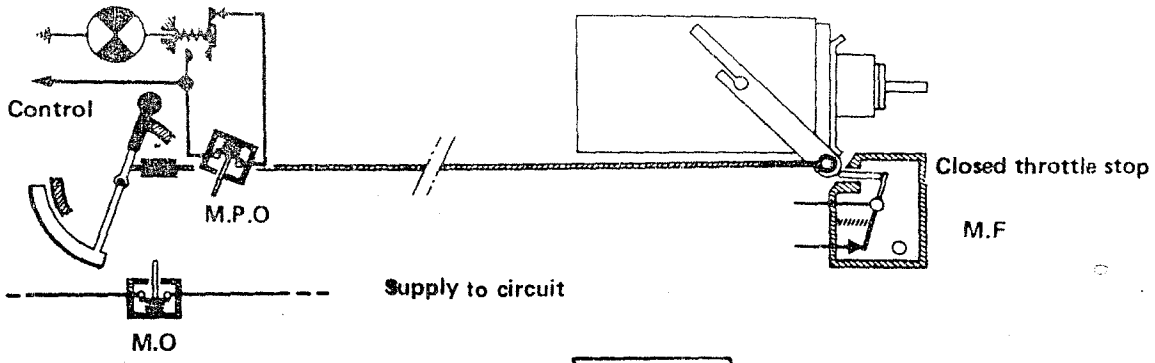
This light indicates the ignition sequence. It is "on" a few seconds at beginning of starting and a flash during stopping.

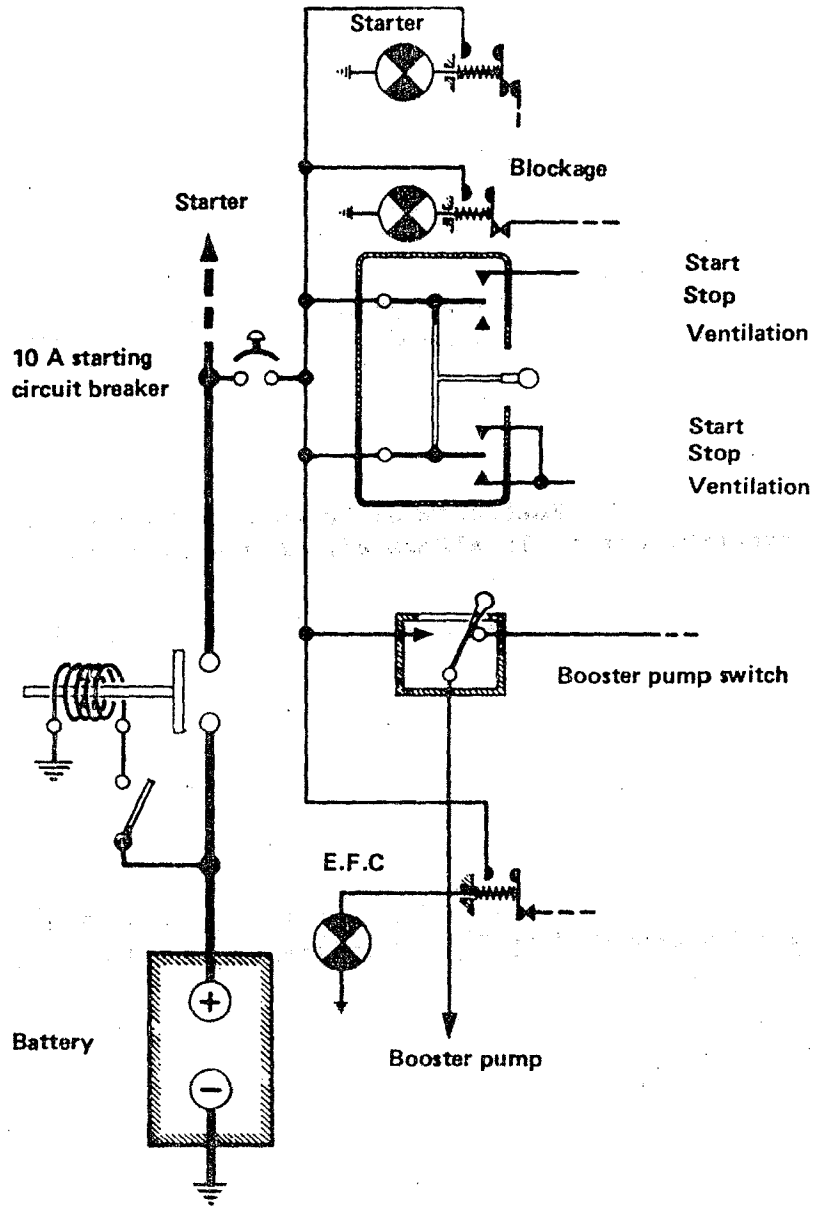
Blockage light (red)

This light indicates the stop sequence and a fault in the system.

Lever opening light (red)

This light indicates the lever full opening. It is "on" as long as the lever is not fully opened.


Control
M.P.O
Closed throttle stop
M.F
Supply to circuit
M.O


Starter
Blockage
Starter
Start
Stop
Ventilation
10 A starting
circuit breaker
Start
Stop
Ventilation
Booster pump switch
E.F.C
Battery
Booster pump

ENGINE ACCESSORIES

Starter-generator

Ensures the cranking of the rotating assembly during starting and the production of electric current during engine operation.

Micro-pump

This pump supplies the torch-igniters with fuel. It is driven by an electric motor of "shunt" type. The micro-pump assembly is provided with a microswitch actuated by the fuel pressure.

Starting valve

It is an electro-valve ensuring a fuel draining overboard during the ignition phase of engine. It is electrically supplied together with the micro-pump and the ignition coil.

Ignition coil

It transforms the direct current of low tension from the battery into high tension current to produce sparks on the torch-igniters. It is a dual coil (one coil for each igniter) of high tension type.

Electric fuel cock

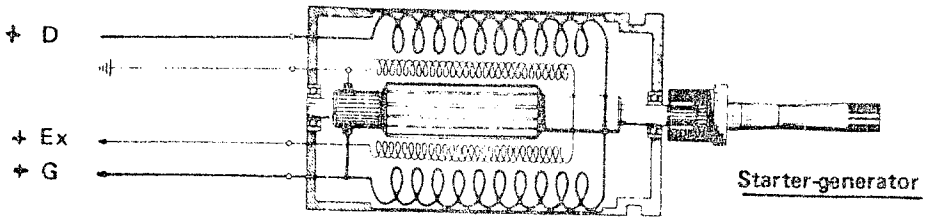
Fuel cock of "open-close" type actuated by a split-field electric motor. It allows engine starting or stopping by opening or closing the fuel flow.

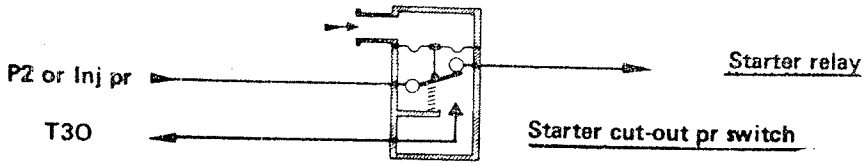
The fuel cock incorporates two "limit-switches" which are mechanically actuated by a cam during the rotation of the fuel cock electric motor.

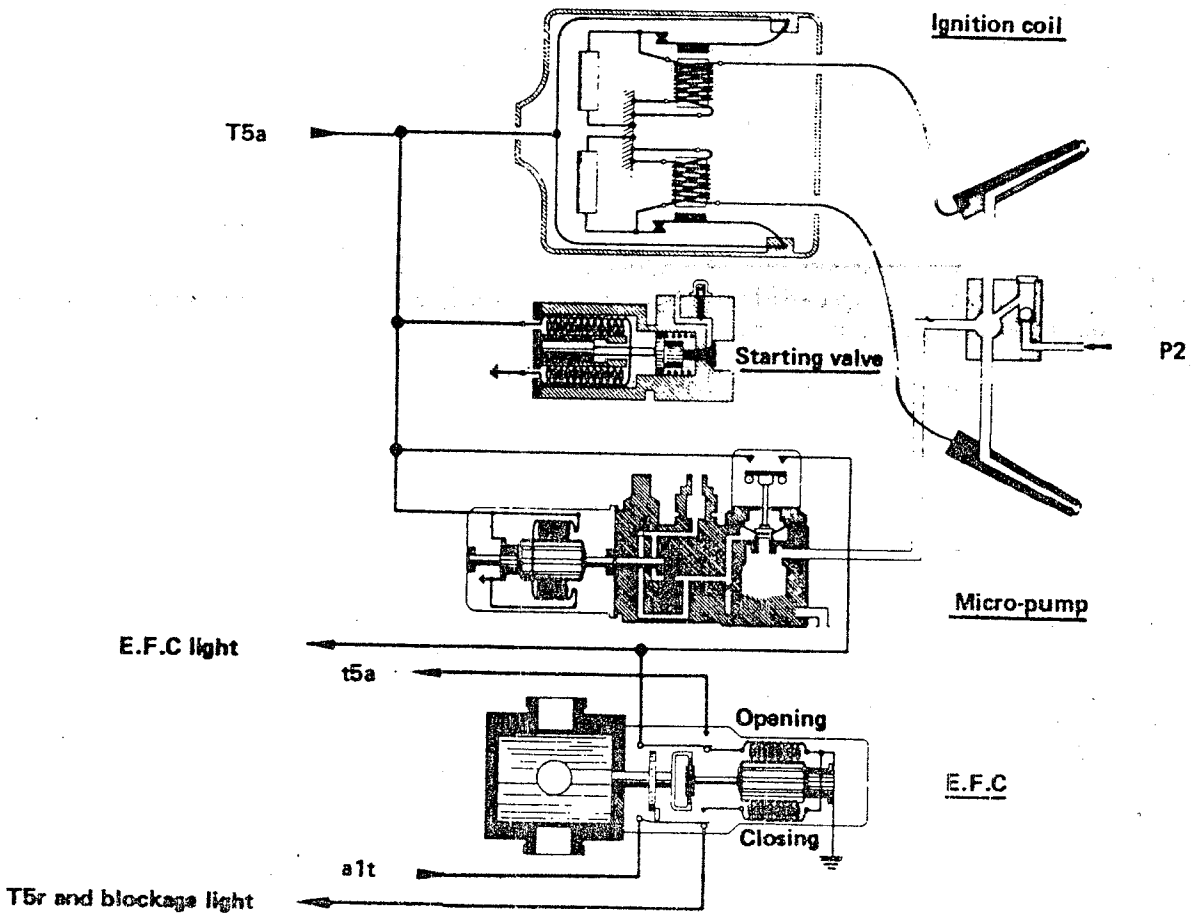
Starter cut-out switch

It ensures the starter cut-out when the engine reaches a certain rotation speed.

Two types of starter cut-out switch can be considered : one is actuated by P2 air pressure, the other one is actuated by the fuel pressure.


D
Ex
G
Starter-generator


P2 or Inj pr
T30
Starter relay
Starter cut-out pr switch


Ignition coil
T5a
Starting valve
P2
Micro-pump
E.F.C light
t5a
Opening
E.F.C
Closing
a1t
T5r and blockage light

AUTOMATIC CONTROL BOX

The box ensures the automatic organization of all the operating phases and also the linking of the electric systems.

It essentially consists of the following components :

Starter relay (or starter contactor)

This relay controls three contacts. The main contact which ensures the supply with high intensity to the starter, and two auxiliary contacts used in the automatic control system.

Relay "a" (a=arrêt=stop)

This relay controls three contacts used in the automatic control system. When energized, it causes engine stopping.

Relay "m" (m=marche=on)

This relay controls three contacts used in the automatic control system. It is essentially used for engine starting.

Time-delay switch T5 a

Time-delay switch with bimetal strip which determines the duration of the ignition sequence. It controls the microswitch T5.

Time-delay switch T5

Time-delay switch with bimetal strip which determines the duration of electric system resetting at engine stopping.

Time-delay switch T30

Time-delay switch which determines the maximum duration of the starting sequence.

RT 30

It is a resistor which limits the heating current of the time-delay switch T30 during the starting sequence.

R a

Voltage drop resistor in the earth circuit of the relay "a". It permits the setting of the relay "a" shunts.

R m

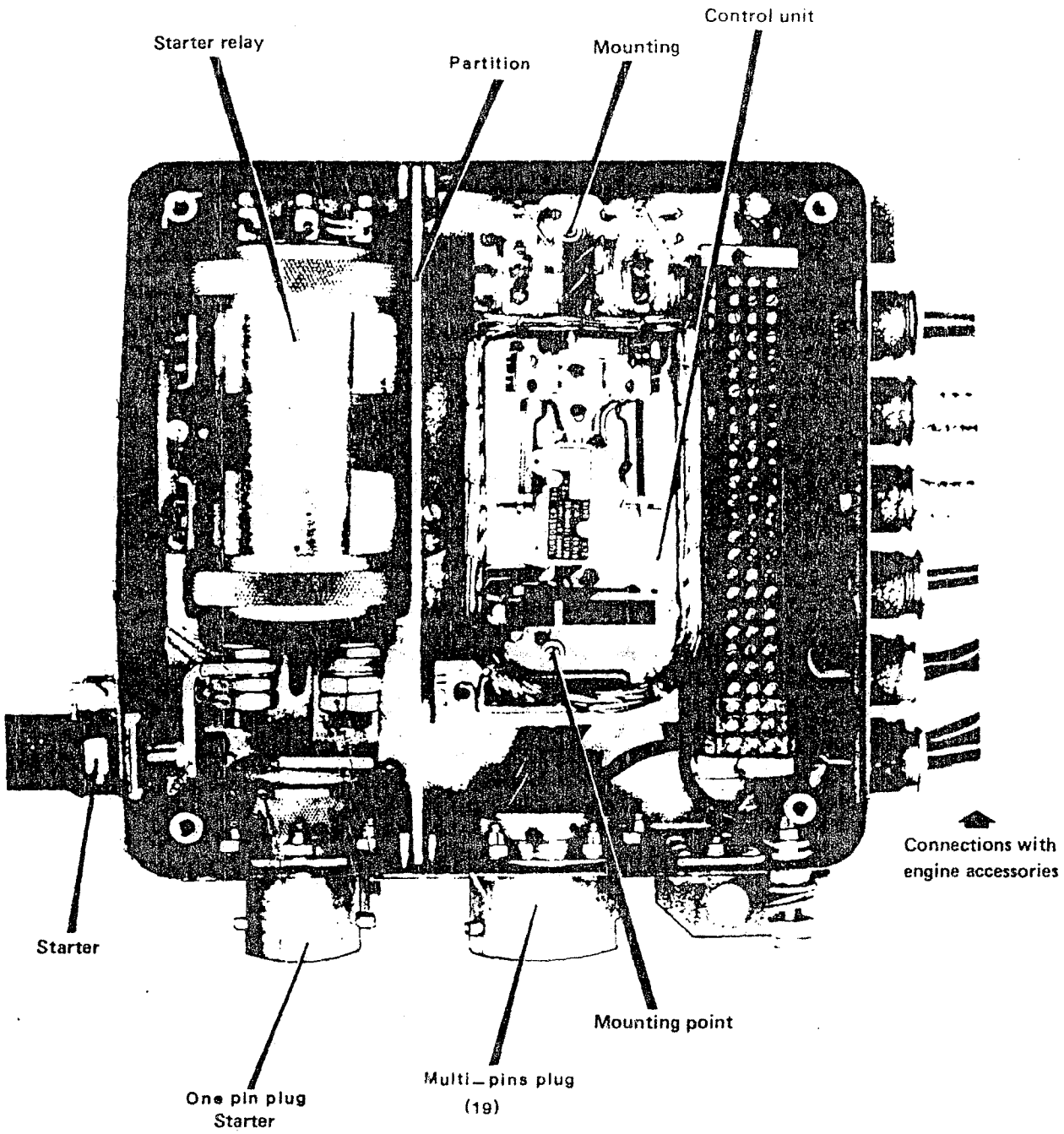
Voltage drop resistor in the earth circuit of the relay "m". It permits the setting of the relay "m" shunts.

R T 5

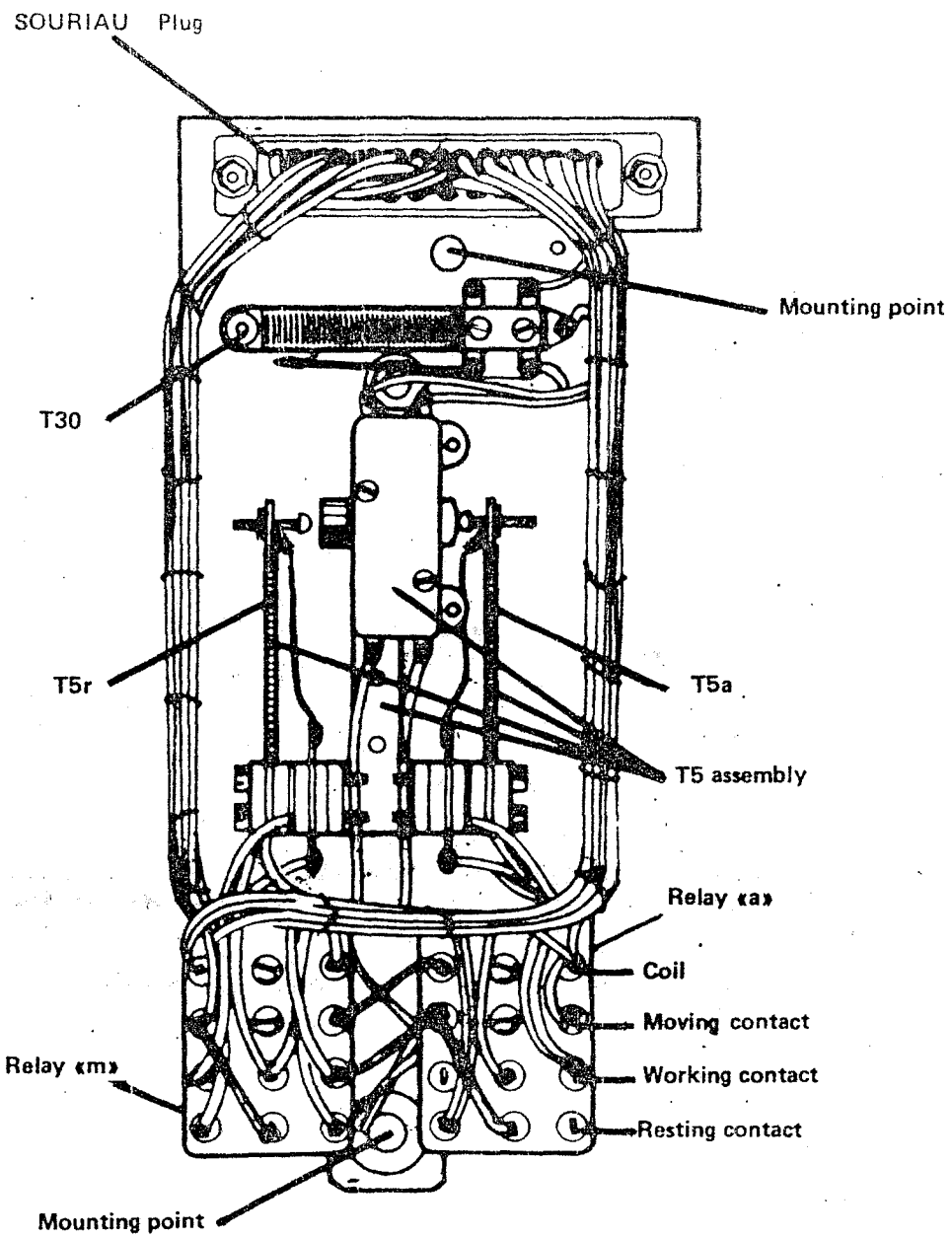
It is a resistor which limits the heating current of the time-delay switch T5r at engine stopping.

Diode

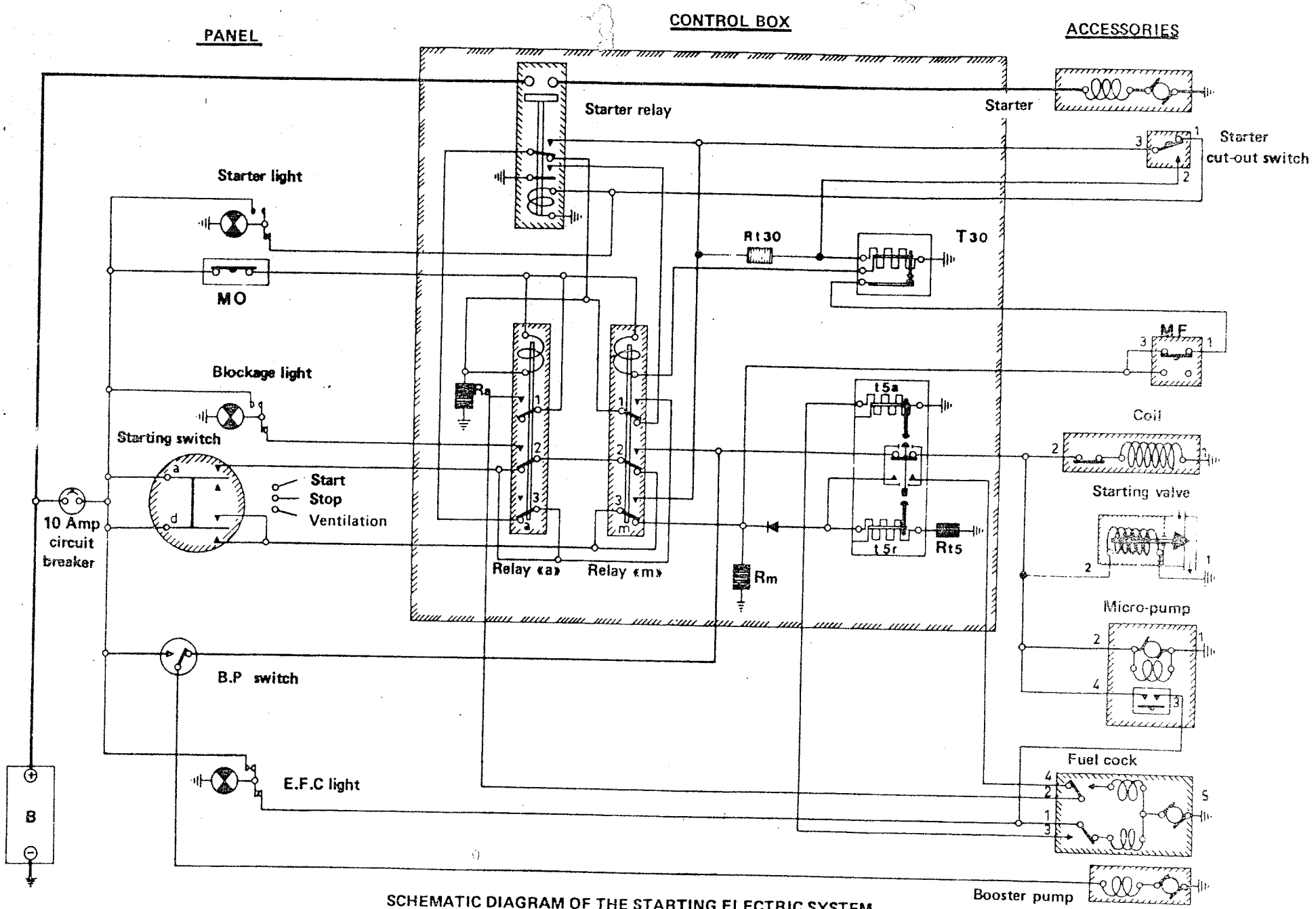
Avoids the permanent heating of the time-delay switch T5 r.



AUTOMATIC CONTROL BOX (EXTERNAL VIEW)



MOVING CONTROL UNIT (VIEW FROM THE FRONT)



SCHEMATIC DIAGRAM OF THE STARTING ELECTRIC SYSTEM

OPERATION OF THE SYSTEM

INTRODUCTION

The various phases of operation are manually and automatically controlled in a well determined order. In a schematic way, the following sequences can be considered :

Starting

Manual sequence

- Power on the electric system
- Starter switch to "start"

Automatic sequence

- Action of micro-pump microswitch
- Fuel cock opening and contact tripping
- Action of the time-delay switch T5a
- Action of the starter cut-out switch
- Action of the time-delay switch T30.

Stopping

Manual sequence

- Control lever to start (fully closed)
- Starter switch to "stop".

Automatic sequence

- Fuel cock closing and tripping of the limit-switches
- Action of the time-delay switch T5r.

Ventilation

Manual sequence

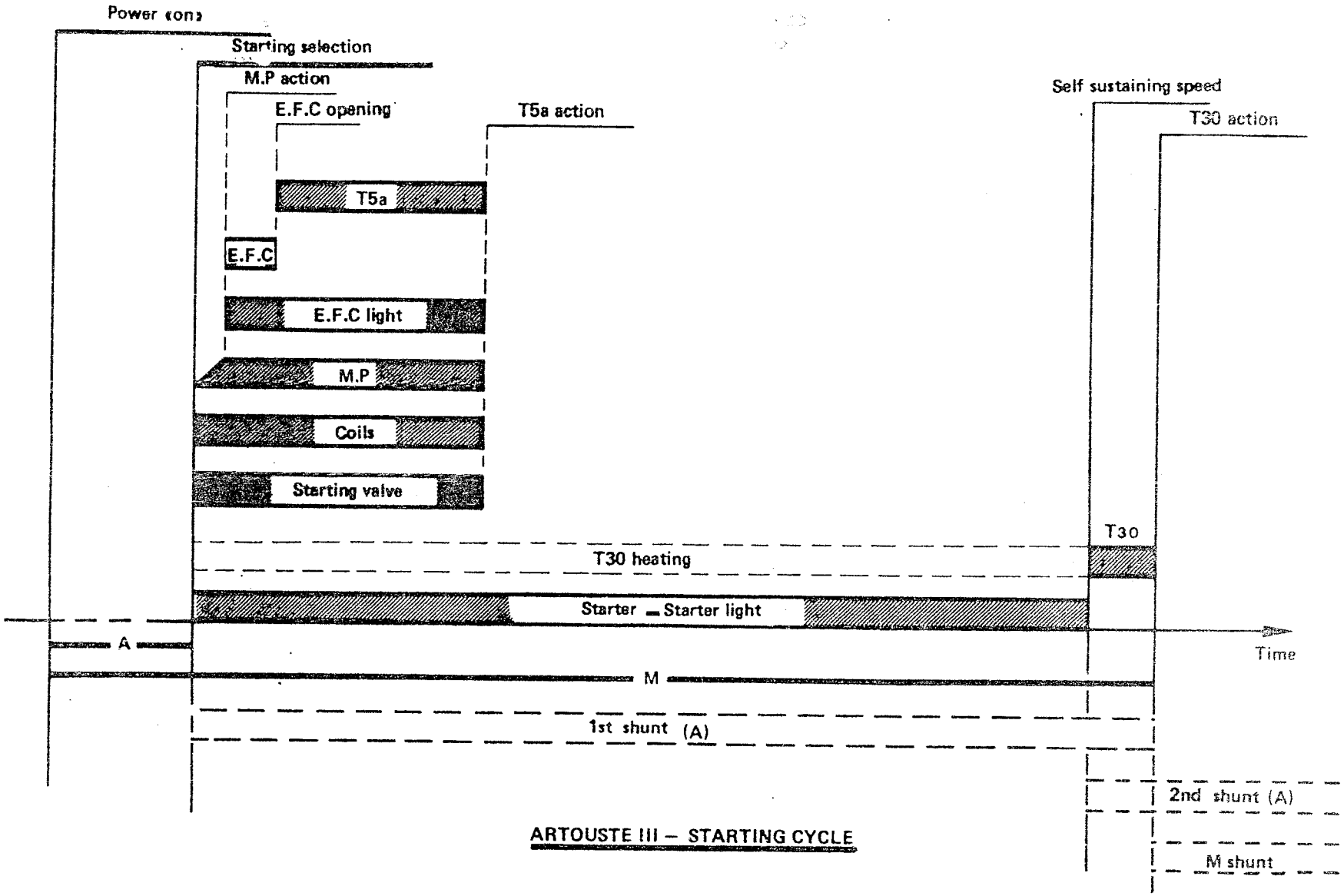
- Power on the electric system
- Starter switch to "ventilate".

Automatic sequence

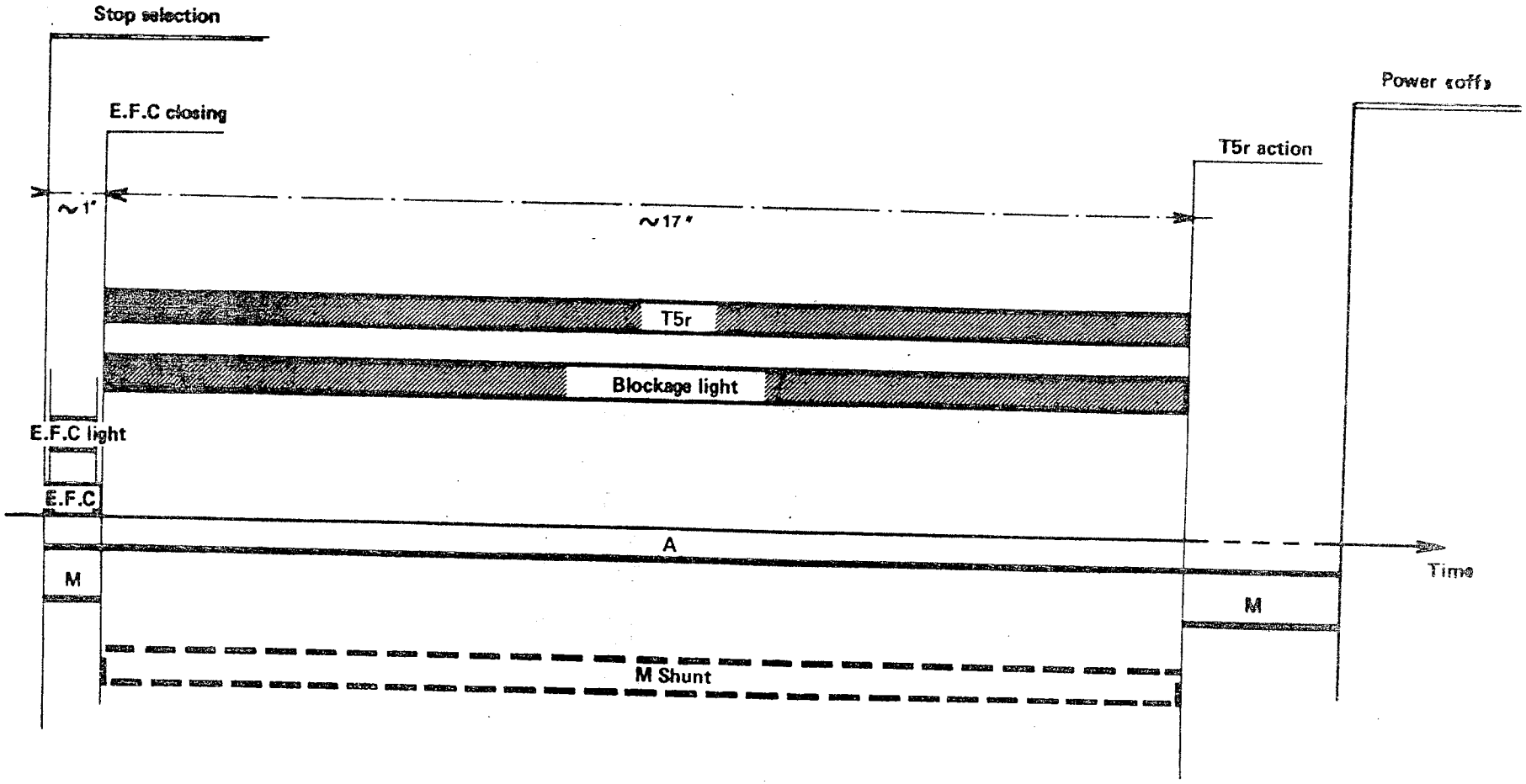
- Action of the time-delay switch T30.

Various cases

- Non ignition of the chamber
- Safeties.



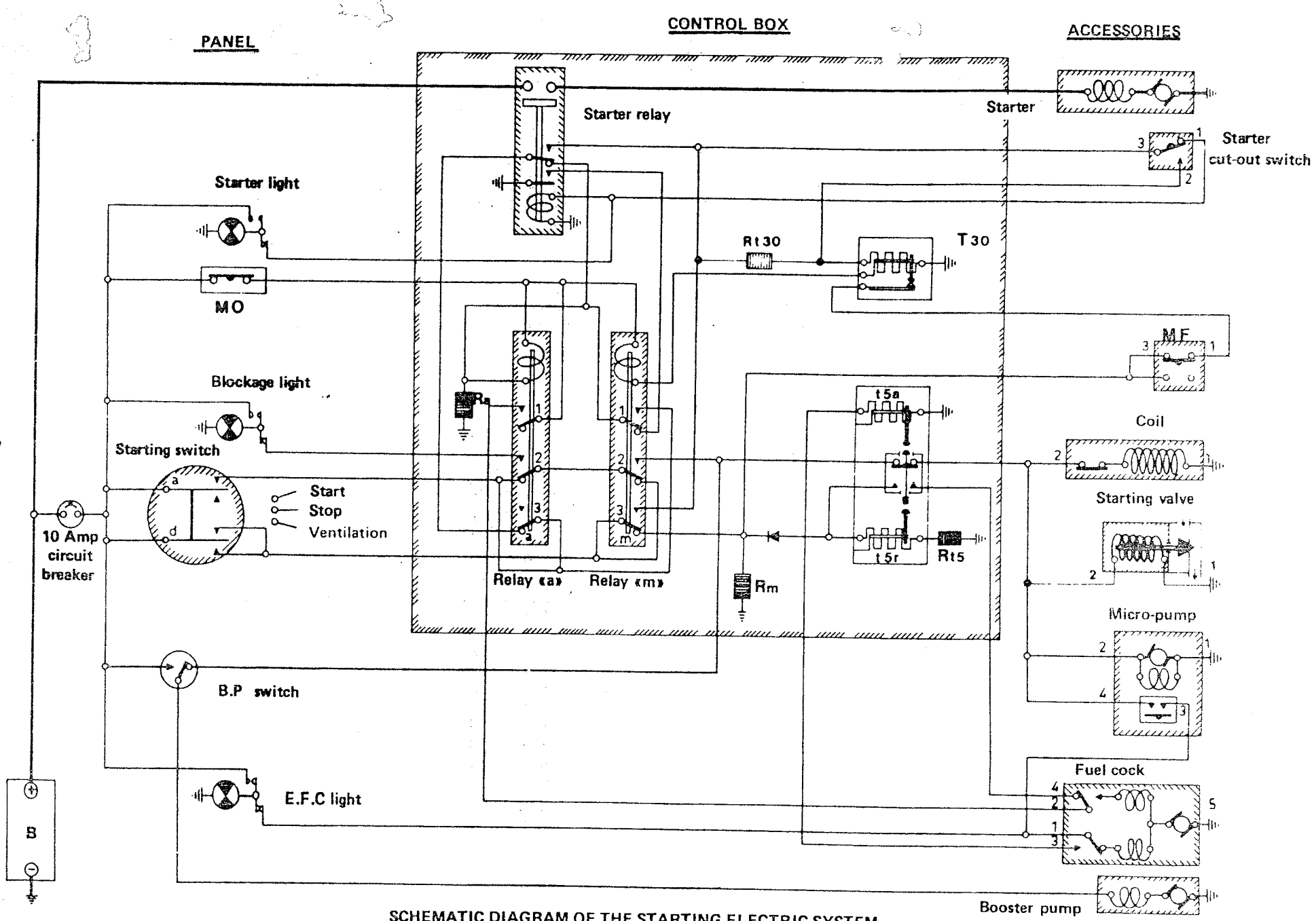
ARTOUSTE III – STARTING CYCLE



ARTOUSTE III – STOPPING CYCLE

POSITION OF THE SYSTEM BEFORE STARTING (see general diagram)

- Fuel flow valve control to "start" (fully closed)
- Engine stopped
- Electric fuel cock closed
- Starter switch to "stop"
- No electric power on the system.



SCHEMATIC DIAGRAM OF THE STARTING ELECTRIC SYSTEM

SETTING POWER ON THE SYSTEM (switch and circuit-breaker engaged)

Supply to relay "a" through :

- circuit-breaker
- microswitch "MO"
- coil of the relay "a"
- resistance Ra
- earth

Supply to relay "m" through :

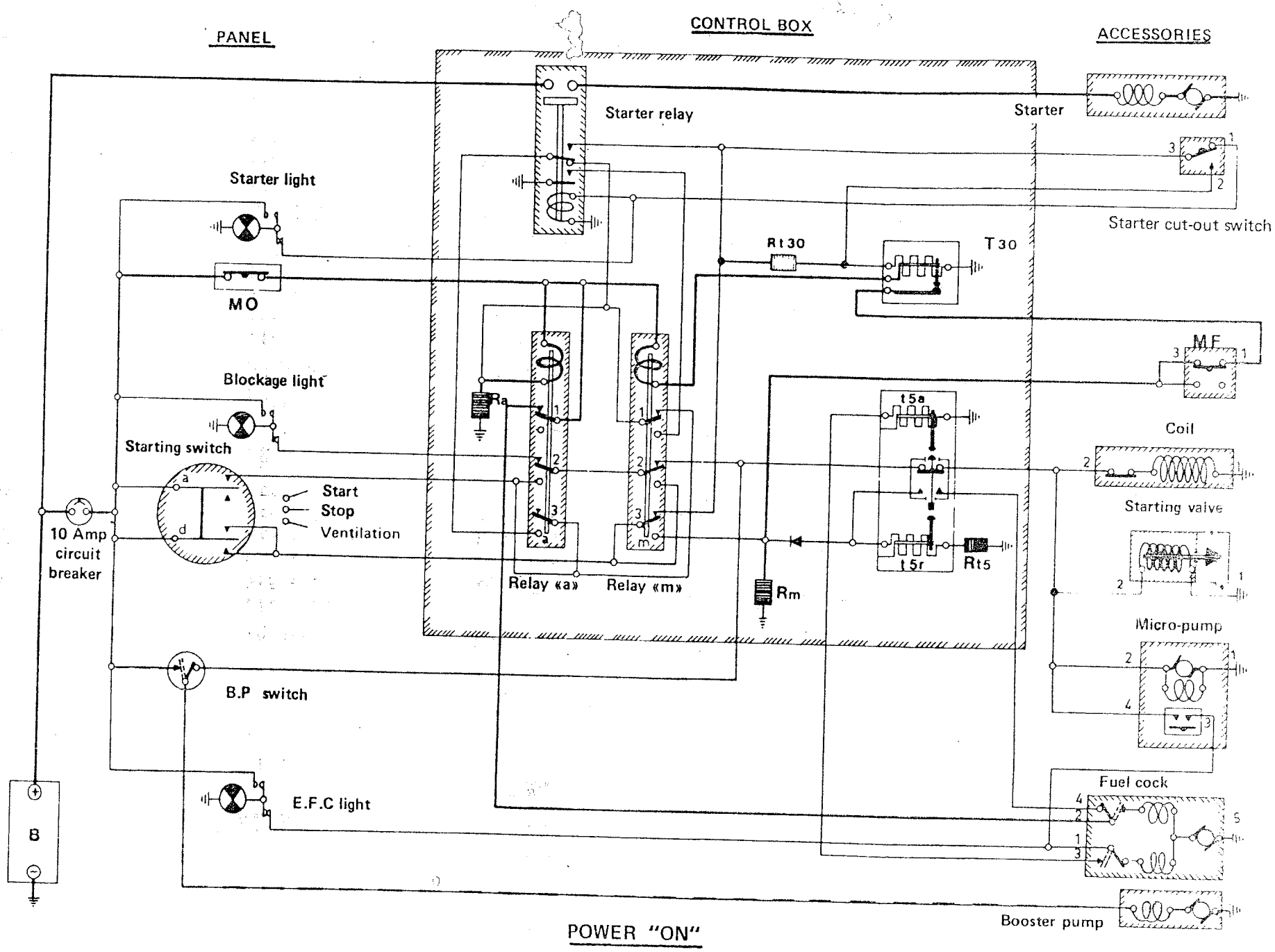
- circuit-breaker
- microswitch "MO"
- coil of the relay "m"
- time-delay switch T30
- microswitch "MF"
- resistance "Rm"
- earth

Supply to electric fuel cock through :

- circuit-breaker
- microswitch "MO"
- working contact nr 1 of the relay "a" (a1 t)
- fuel cock (supply to the coil if the cock is not closed).

DIAGRAM

Red - supply to relays.


PANEL
CONTROL BOX
ACCESSORIES
Starter relay
Starter
Starter light
MO
Starter cut-out switch
Rt30
T30
MF
Blockage light
Ra
t5a
Coil
Starting switch
Start
Stop
Ventilation
10 Amp
circuit
breaker
Relay «a»
Relay «m»
Rm
t5r
Rt5
Starting valve
Micro-pump
B.P switch
Fuel cock
E.F.C light
B
Booster pump

POWER "ON"

STARTER SWITCH TO "START"

Setting of a relay "a" shunt through :

- circuit-breaker
- starter switch to "start"
- m 1 t
- relay "a" coil outlet
  (relay "a" is released)

Supply to starter relay through :

- circuit-breaker
- starter switch to "start"
- m 3 t
- starter cut-out switch (resting contact)
- green light
- starter relay coil.

Supply to starter motor through :

- main contact of the starter relay
- starter motor, earth

Reduced supply to time-delay switch T30 through :

- circuit-breaker
- starter switch to "start"
- m 3 t
- RT 30
- T 30, earth (the T30 is slowly heated)

Supply to micro-pump, coil and valve through :

- circuit-breaker
- starter switch to "start"
- a 2 r
- m 2 t
- T 5

Reinforced supply to ignition accessories through :

- circuit-breaker
- starter switch to "start"
- m 3 t
- auxiliary contact of the starter relay
- a 3 r
- a 2 r

Automatic supply to booster pump through :

- circuit-breaker
- starter switch to "start"
- a 2 r
- m 2 t
- booster pump switch to "automatic"
- booster pump.

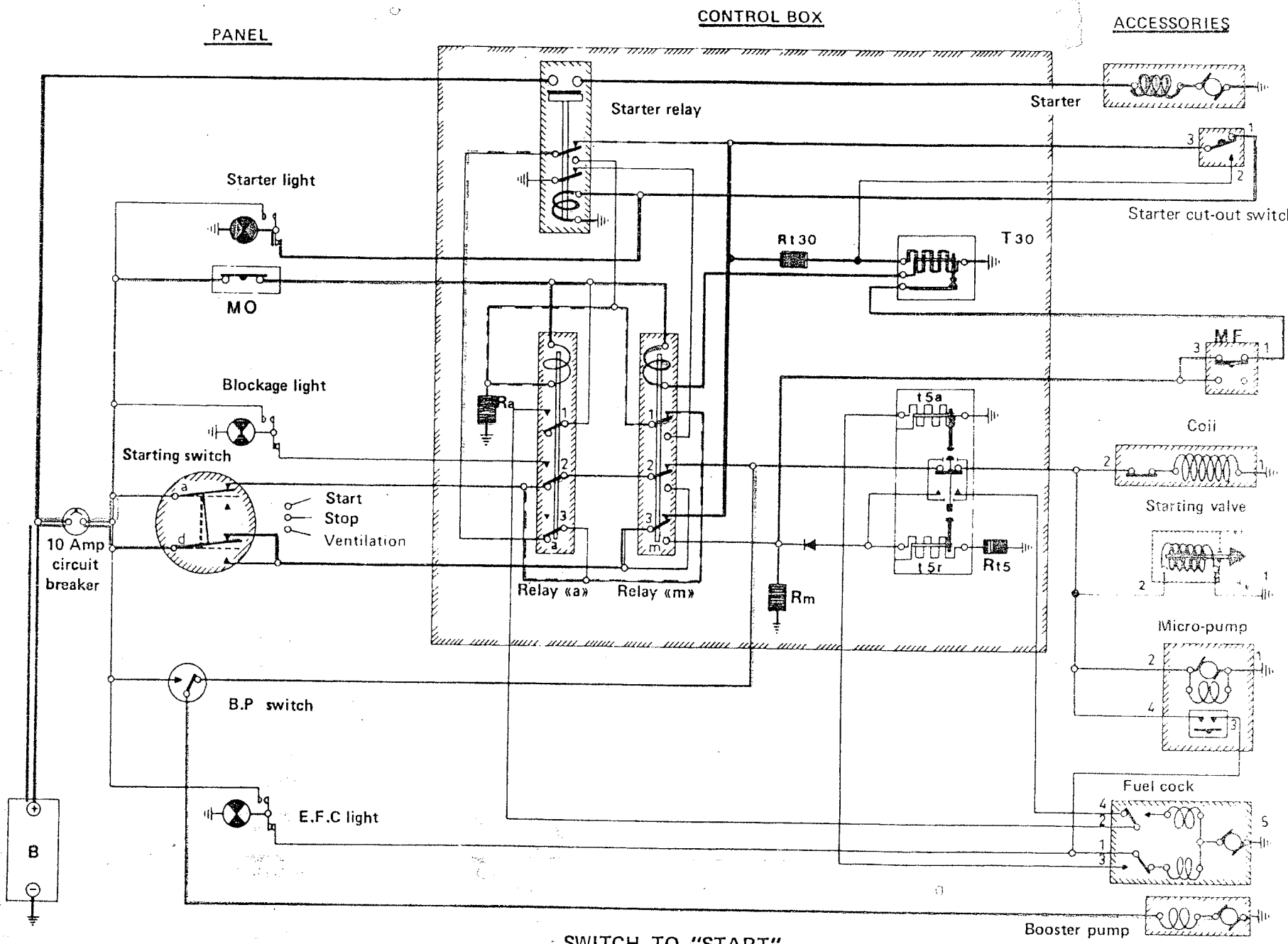
DIAGRAM

red - supply to relay

dotted red - relay "a" shunt

green - starter

yellow - ignition.



SWITCH TO "START"

ACTION OF THE MICRO-PUMP MICROSWITCH

Supply to electric fuel cock and E.F.C. light through :

- circuit-breaker
- starter switch to "start"
- a 2 r
- m 2 t
- T 5
- micro-pump microswitch contact
- yellow light
- fuel cock opening coil.

Fuel cock opening and tripping of the limit-switches

- the electric fuel cock opens
- the limit-switches change over.

Supply to the time-delay switch T 5 a through :

- circuit-breaker
- starter switch to "start"
- a 2 r
- m 2 t
- T 5
- micro-pump microswitch contact
- electric fuel cock limit-switch
- T 5 a.

ACTION OF THE TIME-DELAY SWITCH T 5 a

Tripping of the T 5 a contact causing :

- micro-pump cut-out
- ignition coil cut-out
- starting valve cut-out
- electric fuel cock yellow light turning "out".

DIAGRAM

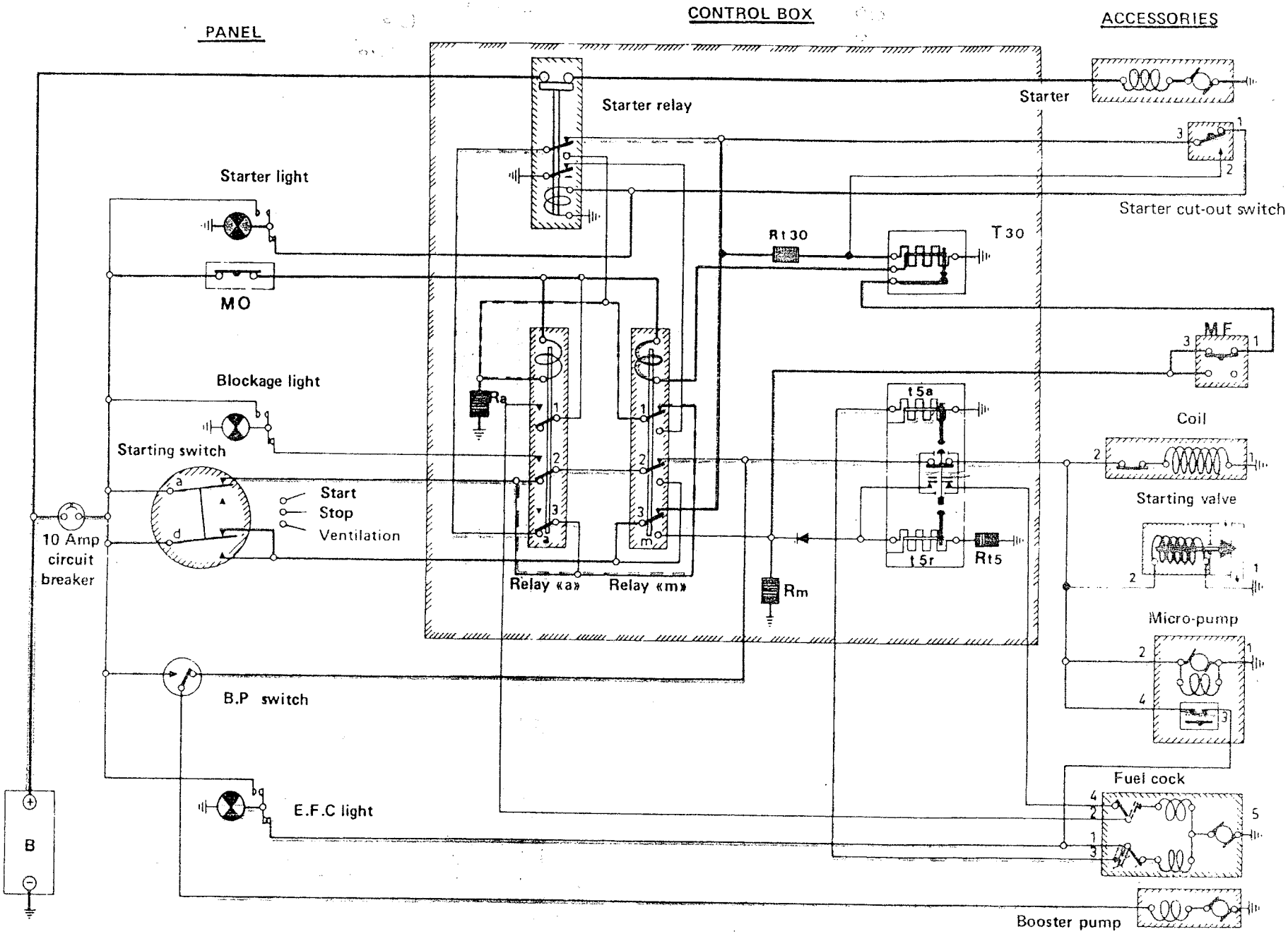
red - relay

dotted red - relay "a" shunt

green - starter

yellow - ignition

dotted yellow - T 5.



M. P. MICROSWITCH ACTION - T5a ACTION

ACTION OF THE STARTER CUT-OUT SWITCH

When the engine reaches a certain speed (self-sustaining speed) the pressure switch changes over its contact.

Tripping of the pressure switch contact

Cut-out of the supply to light and starter relay

cut-out made by tripping of the pressure switch

Cut-out of the supply to starter

cut-out due to starter relay de-energizing

Direct supply to the time-delay switch T30 through :

- circuit-breaker
- starter switch to "start"
- m 3 t
- pressure switch (working contact)
- T 30 (resistance)
- earth

Setting of the relay "a" second shunt through :

- circuit-breaker
- starter switch to "start"
- a 3 r
- resting auxillary contact of the starter relay
- "a" coil outlet.

ACTION OF THE TIME-DELAY SWITCH T 30

Cut-out of the supply to relay "m"

The T 30 opening cuts the earth of the relay "m"

Cut-out of the first shunt of relay "a"

Due to m 1 contact coming back to rest

Cut-out of the automatic supply to booster pump

Due to m 2 coming back to rest

Setting of the relay "m" shunt through :

- circuit-breaker
- starter switch
- m 3 r
- MF
- T 30
- "m" coil outlet.

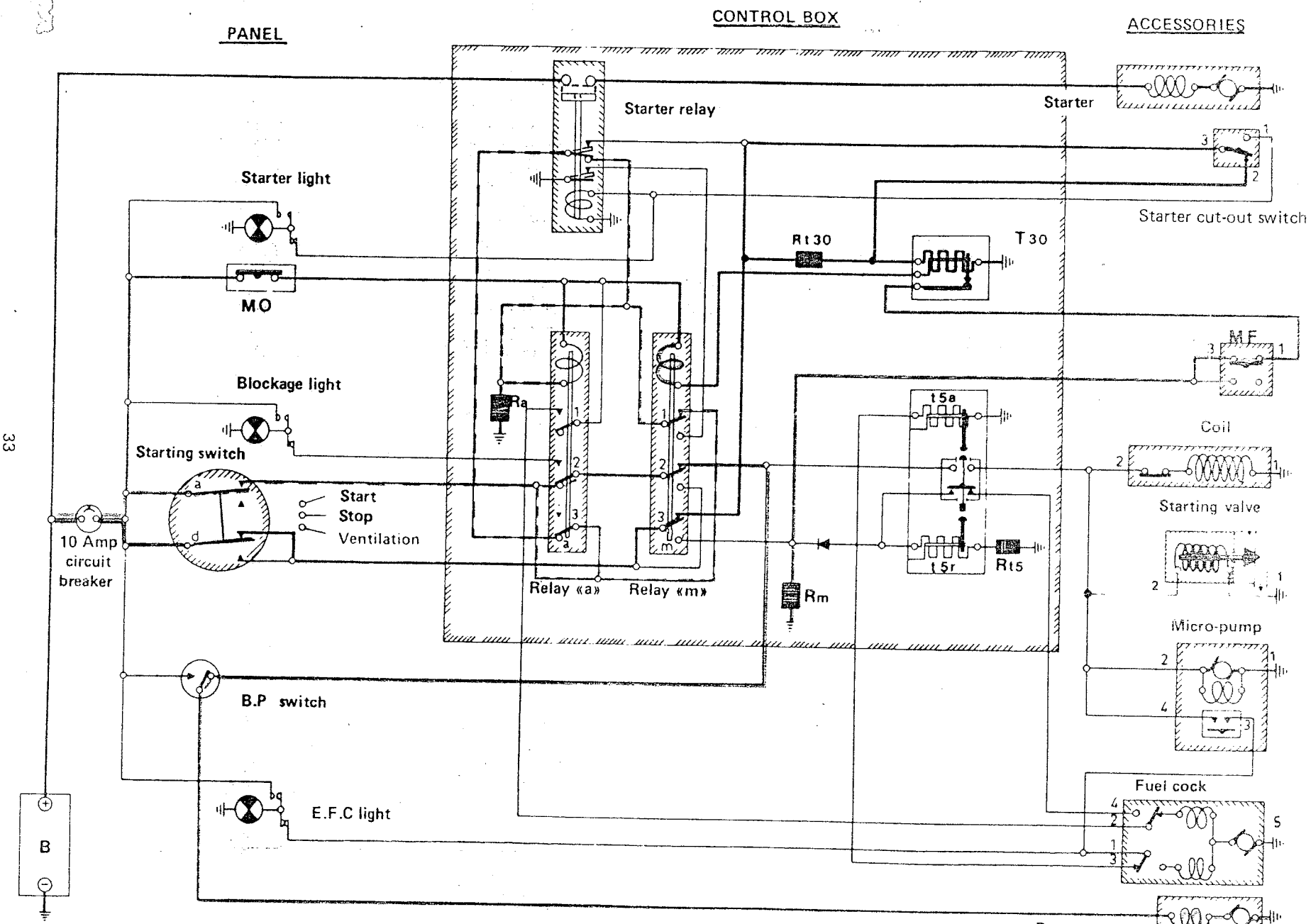
DIAGRAM

red - relay

dotted red - relay shunt

green - starter

yellow - ignition.



STARTER CUT-OUT SWITCH ACTION - T30 ACTION

OPERATION DURING ENGINE STOPPING

Closing of the control lever

- deceleration down to idling
- tripping of the microswitch contacts
- supply to relays "a" and "m" (however, the relays remain at rest by reason of the two shunt circuits)

Starter switch to "stop"

Cut-out of the relay "a" shunt and of the relay "m" shunt

Supply to relay "a" through : circuit-breaker, MO, "a", Ra, earth

Supply to relay "m" through : circuit-breaker, MO, m, T30, MF, Rm, earth

Supply to fuel cock through : circuit-breaker, MO, a l t, fuel cock limit-switch, fuel cock closing coil, earth

Tripping of the fuel cock opening limit-switch

Supply to fuel cock light through : circuit-breaker, MO, alt, fuel cock closing coil, fuel cock opening coil, yellow light, earth.

Tripping of the fuel cock closing limit-switch

Cut-out of the supply to light

Supply to time-delay switch T5 R through : circuit-breaker, MO, alt, fuel cock limit-switch, T5, T5r, Rt5, earth

Setting of the relay "m" shunt through : T5, diode, MF, T30, "m" coil outlet.

Supply to blockage light through : T5, diode, m3r, m2r, a2t, light, earth.

Action of the time-delay switch T5r

Resetting of the microswitch T5

Cut-out of the relay "m" shunt

Energizing of relay "m"

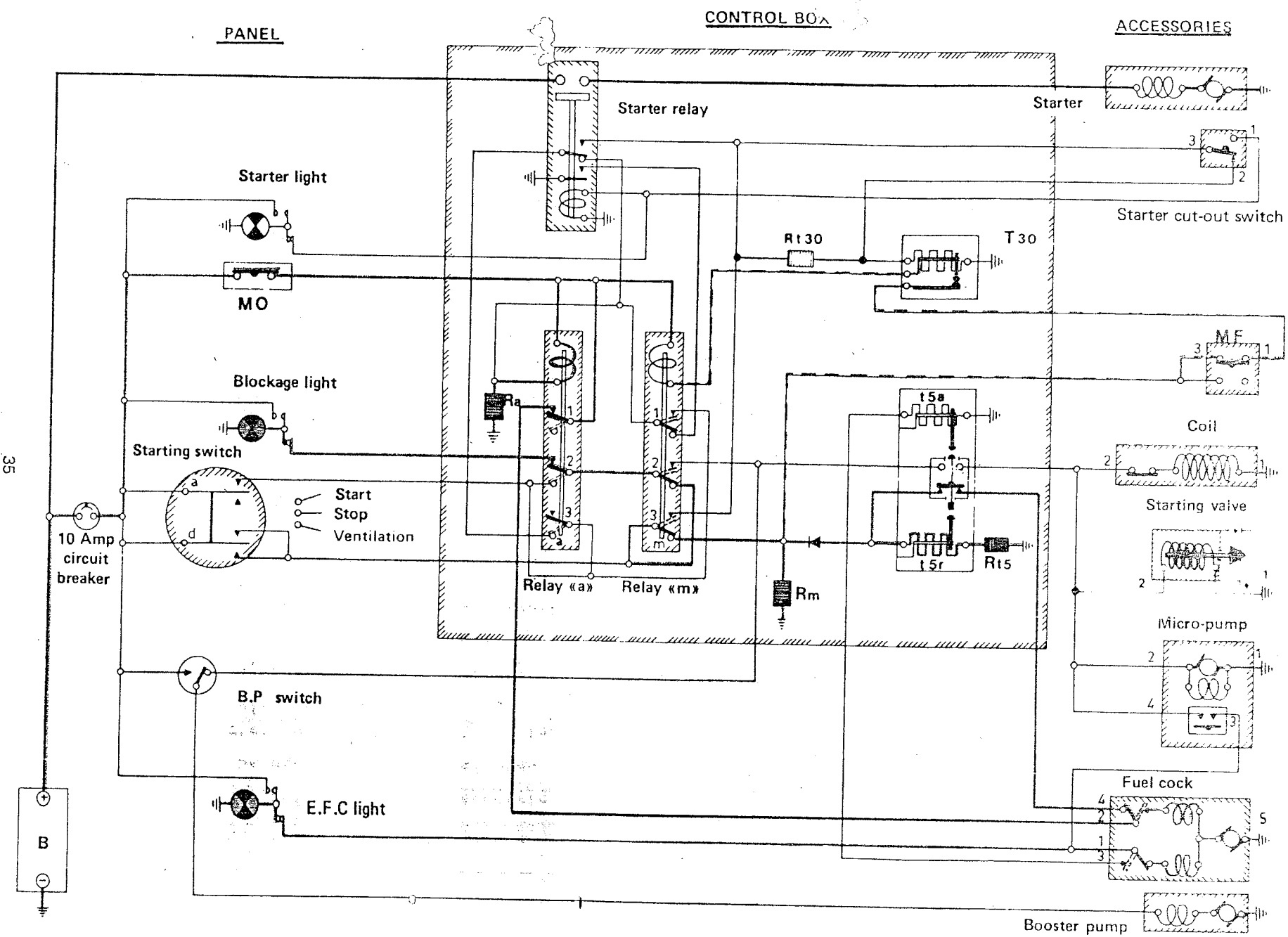
Cut-out of blockage light

The electric system is ready for another starting.

DIAGRAM

red - relay fuel cock closing

yellow - supply to fuel cock light.



ENGINE STOPPING

OPERATION DURING THE VENTILATION SEQUENCE

Setting of power on the electric system

Sequence already considered

Starter switch to "ventilate" (and held in this position)

Supply to light and starter relay through :

- circuit-breaker
- starter switch to "ventilate"
- m 3 t
- starter cut-out switch
- green light
- starter relay

Supply to starter motor through :

- main working contact of starter relay

Supply to time-delay switch T30 through :

- circuit-breaker
- starter switch to "ventilate"
- m 3 t
- RT 30, T 30, earth.

Ventilation cut-out by return to "stop"

Cut-out of the supply to light, relay and T30

due to the switch returning to "stop"

Cut-out of the supply to starter motor

due to starter relay de-energizing

Ventilation cut-out by action of T30

Action of time-delay switch T30

Cut-out of relay "m"

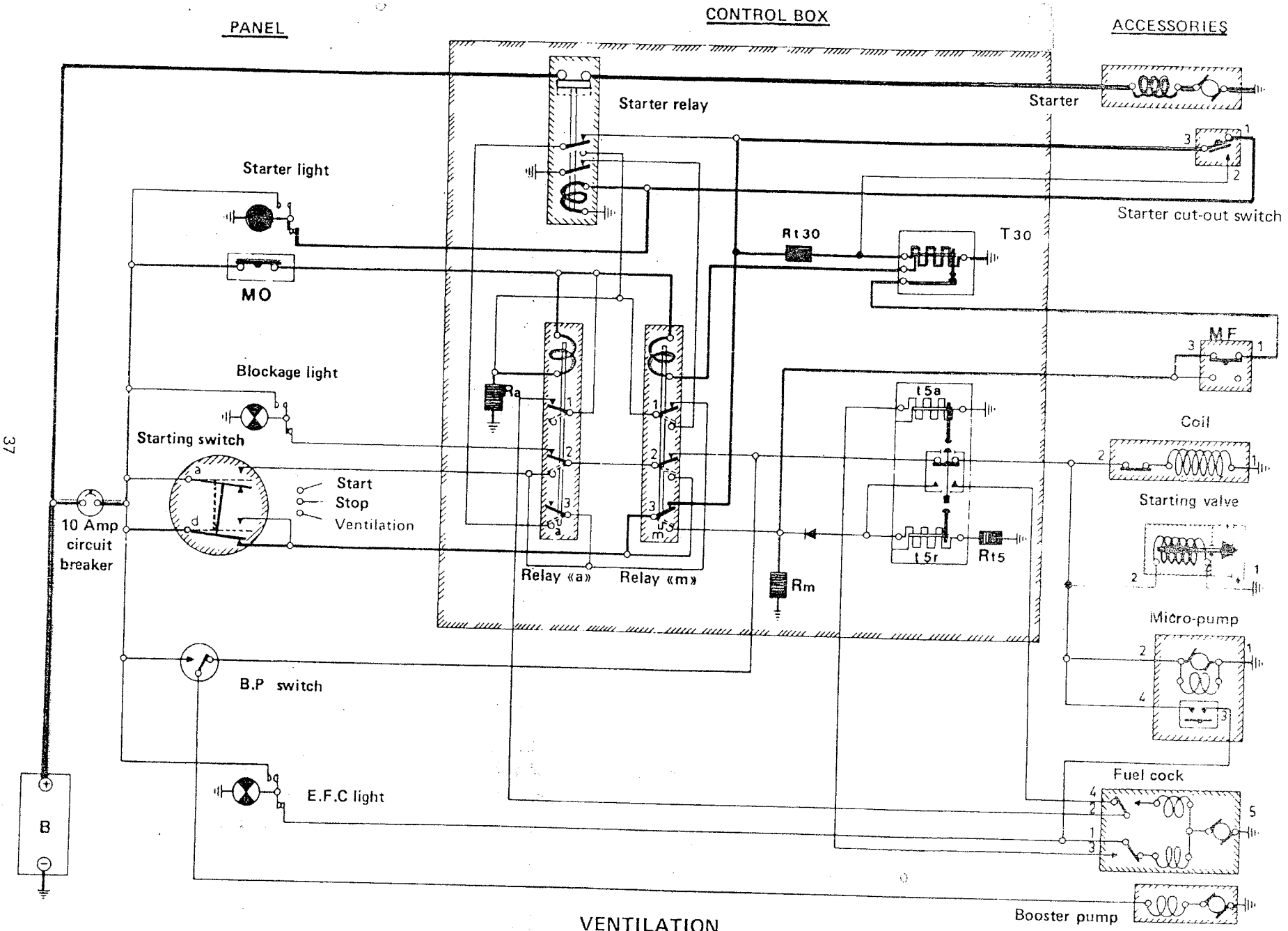
Cut-out of green light, relay and starter

Supply to "blockage" light

DIAGRAM

red - relay

green - starter


PANEL
CONTROL BOX
ACCESSORIES
Starter relay
Starter
Starter light
Starter cut-out switch
Rt30
T30
MO
MF
Blockage light
Ra
t5a
Coil
Starting switch
Start
Stop
Ventilation
10 Amp
circuit
breaker
Starting valve
Relay «a»
Relay «m»
Rm
t5r
Rt5
Micro-pump
B.P switch
Fuel cock
E.F.C light
B
Booster pump
VENTILATION

VARIOUS CASES

Case of too low a starting

If the engine has not reached the self-sustaining speed within a certain time, the time-delay switch T 30 opens its contact and the following sequence is initiated.

Cut-out of the supply to relay "m"

due to contact T 30 opening

Cut-out of the first shunt of relay "a"

due to m 1 returning to resting position

Supply to the relay "a" through : circuit-breaker, MO, m 1 r, auxiliary working contact of the starter relay (during a short time since the starter relay is to be released due to "m" energizing)

Supply to relay "a" holding through : circuit-breaker, MO, "a", Ra, earth

Supply to electric fuel cock through : circuit-breaker, MO, a 1 t, fuel cock limit-switch, coil closing, earth

Supply to yellow light (flash)

T 5 r, relay "m" shunt, blockage light, action of T5 r (normal stop sequence)

Note - In this sequence, the supply to relay "a" is carried out through a direct earth. This supply is necessary given that the too long operating time of the starter leads to such a voltage drop that the relay "a" cannot be energized through the resistance Ra.

MF safety

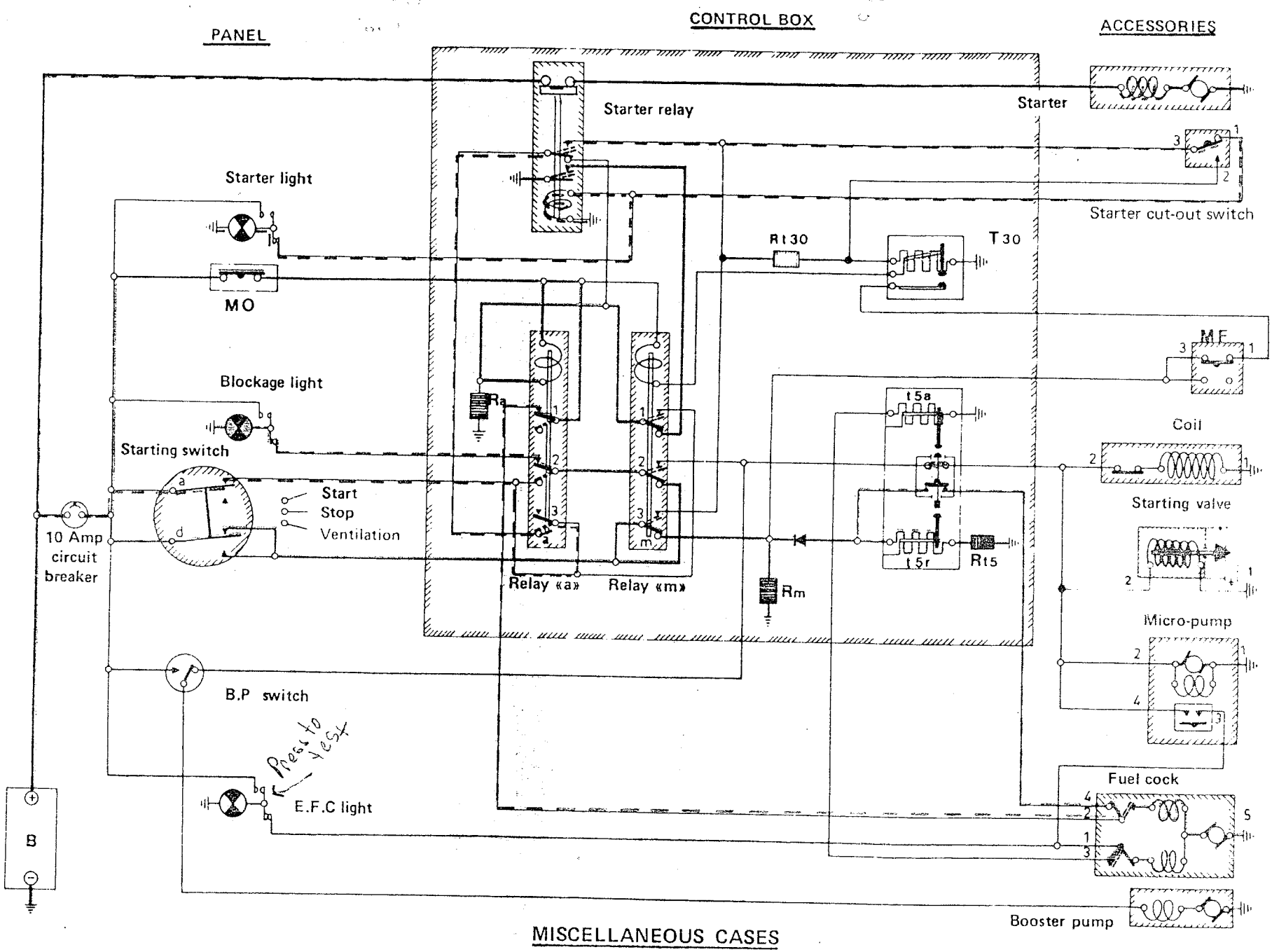
If the lever is not fully closed at starting, the microswitch MF prevents the supply to relay "m" and, consequently, the starting.

By placing the starter switch to "start", the result is only the supply to red blockage light.

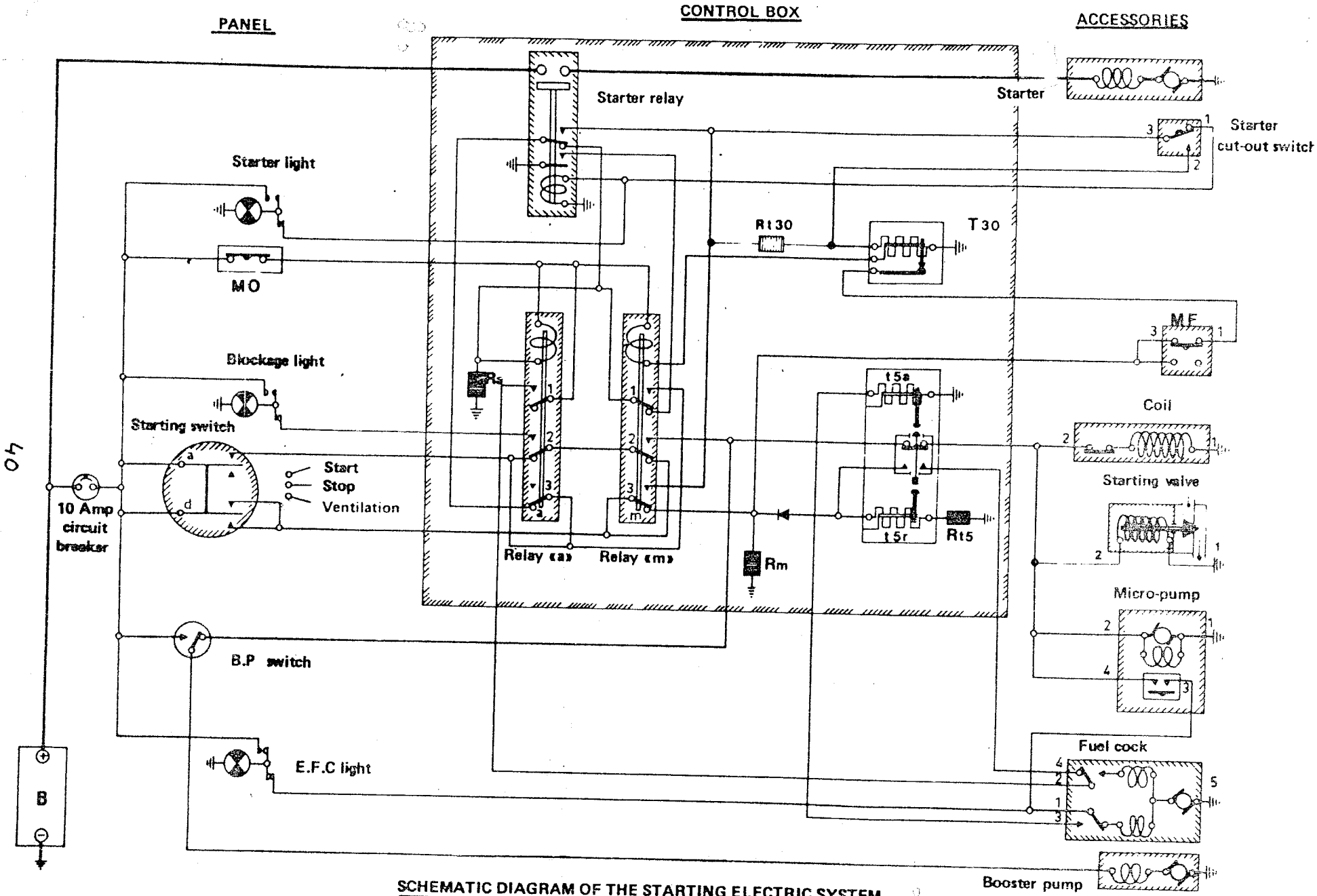
MO safety

Prevents the fuel cock closing when the lever is fully opened.

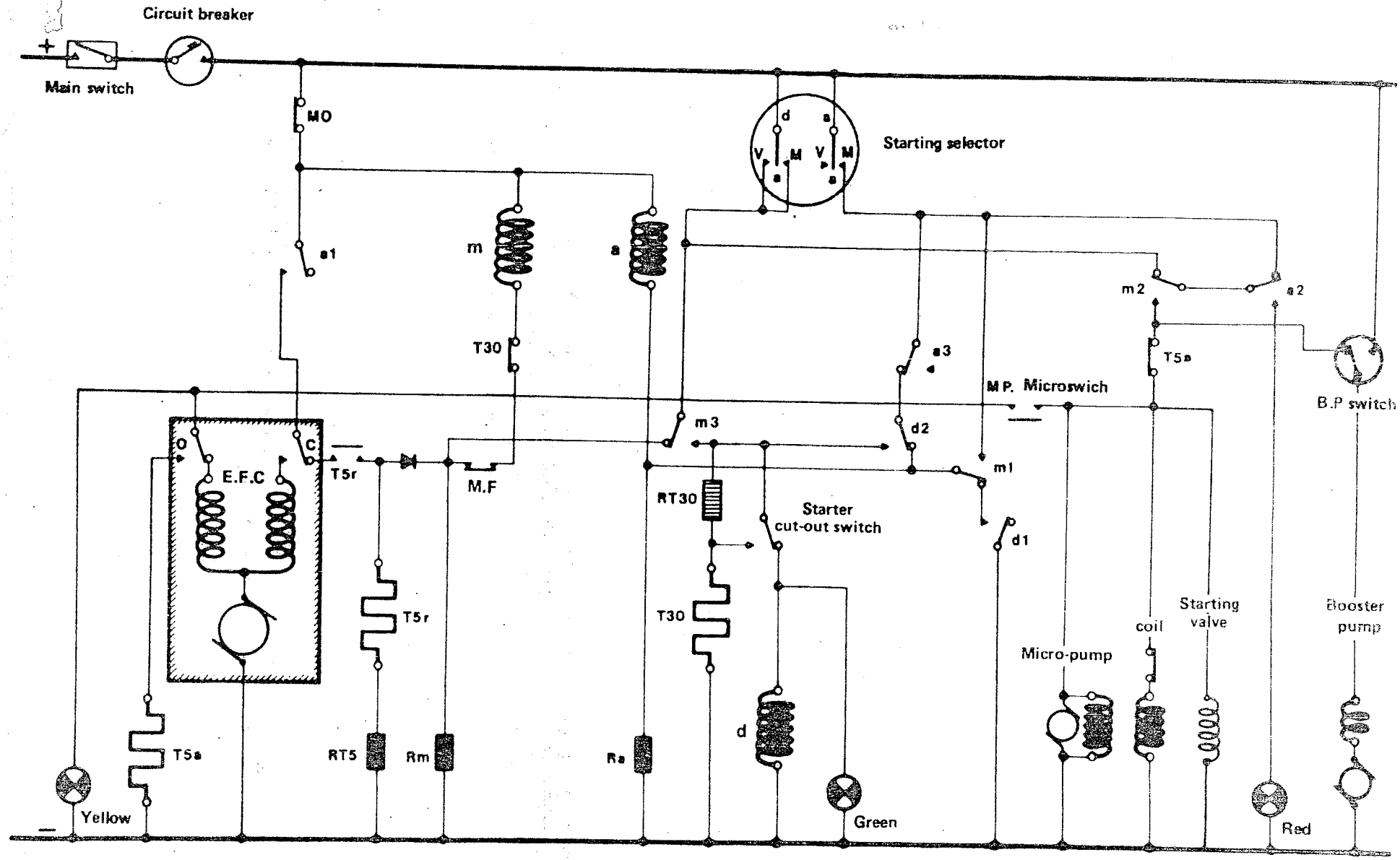
The microswitch MO prevents any supply to the relays of the starting system.



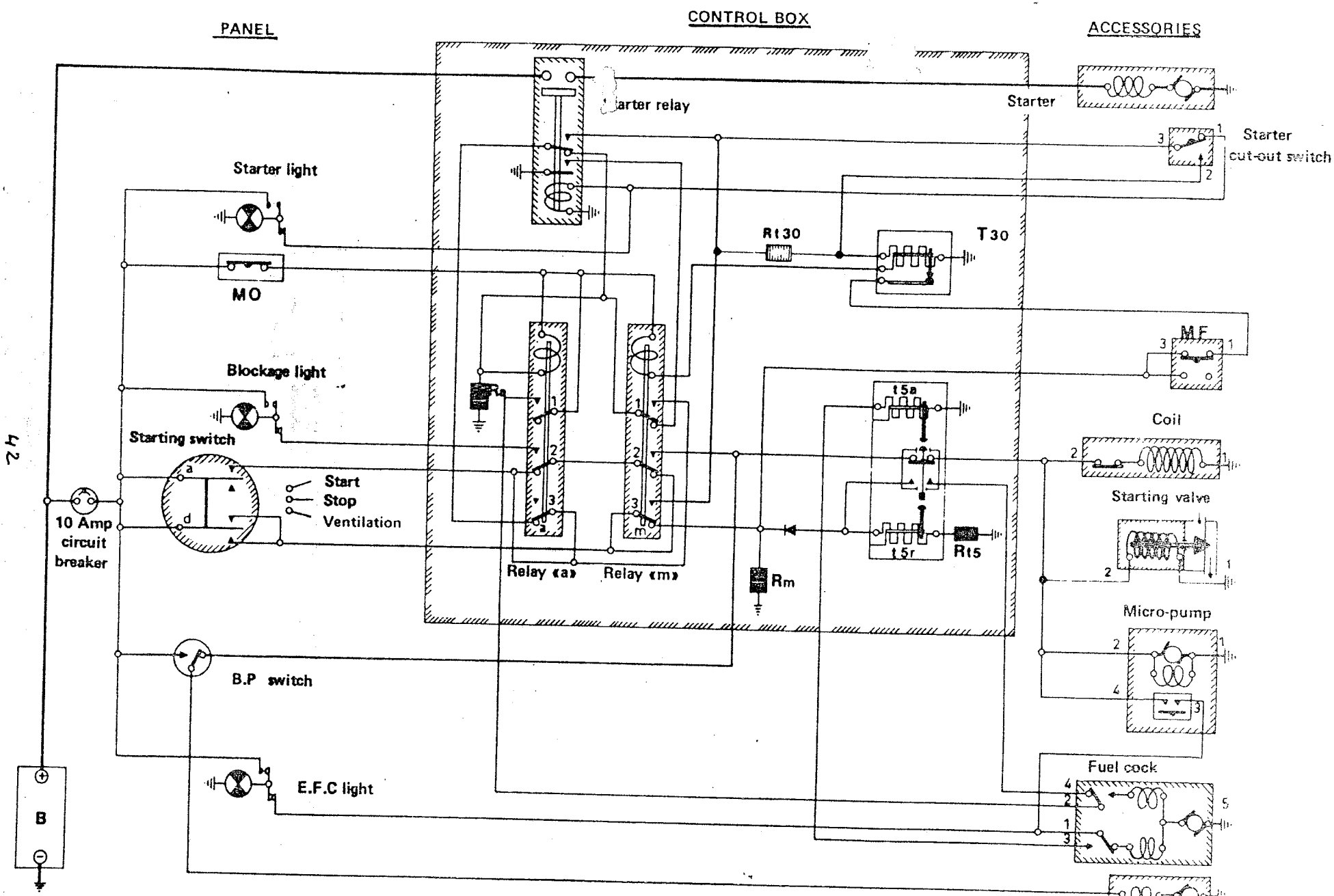
MISCELLANEOUS CASES



SCHEMATIC DIAGRAM OF THE STARTING ELECTRIC SYSTEM



SCHEMATIC DIAGRAM OF THE STARTING ELECTRIC SYSTEM



SCHEMATIC DIAGRAM OF THE STARTING ELECTRIC SYSTEM

MAINTENANCE

INTRODUCTION

The paragraph "maintenance" is arranged according to the following scheme :

- Statement of the main characteristics
- Servicing and maintenance
- Check-out procedures and adjustments
- Fault analysis
- Practical works
- Simulator.

MAIN CHARACTERISTICS

- Nominal voltage of the system	28 v
- Operating voltage of accessories	14 to 30 v
- Battery min. voltage for starting	25.5 v
- Voltage during starting	must remain $>$ 14 v
- Voltage at ignition coil outlet	15,000 v
- Ignition coil intensity	5 A
- Micro-pump intensity	4 A
- Rotation speed of the micro-pump motor	6,000 RPM - max. 15,000 RPM
- Time required for micro-pump pressure building-up	about 1/2 sec.
- Starter-generator power	4 kw
- Starter-generator max. intensity	850 A
- Starter cut-out switch setting	P2 = 0.4 b Pi = 0.35 b
- Rotation speed at starter cut-out	14,000 RPM $\pm$ 1,000
- MF microswitch setting	0°
- MO microswitch setting	1/2travel N= 26,800 RPM
- T5a operating time	3 to 3.5 sec. } under constant "U"
- T5r operating time	16.5 to 20 sec. } under constant "U"
- T30 operating time	50 to 60 sec. } under constant "U"

SERVICING AND MAINTENANCE

In service, check the correct operation of the system by means of the indicating lights and instruments.

Particularly check :

- the supply static tension
- the voltage drop during starting
- the starting time
- the ignition time
- the run-down time.

For periodic and field maintenance, refer to the chapters corresponding to each accessory.

CHECK-OUT PROCEDURES AND ADJUSTMENTS

As regards the engine accessories, refer to corresponding chapters.

As regards the inspection of the electric system operation, it is mainly ensured by means of a simulator and of control boxes. The simulator is considered in a special paragraph of this chapter.

It is worth to mention three possibilities of adjustment in the electric system : the T5a time-delay switch adjustment, the T5r time-delay switch adjustment, and the T30 time-delay switch adjustment.

The check-out procedure and the adjustment of the time-delay switches require a special set of tools. They must be carried out under constant tension and determined ambient temperature.

Note

All the practices made on the electric system are covered in practical works during a training course.

FAULT ANALYSIS

The fault analysis consists in considering the phenomena and symptoms occuring in the case of a defective component. The question is then to proceed from the cause to the effect. The main purpose of this exercise is to acquire a better knowledge of the system. In this paragraph, the analysis is dealt with in a very schematic way for the accessories, the control and indicating components, the components of the automatic control box.

Engine accessories

Ignition coil

The two coils are defective : the electric cycle is normal, but there is no ignition, no rise in t4, and obviously no starting.

One coil is defective : the electric cycle is normal, but the ignition is made on one igniter only ; starting is possible but with difficulties in ignition.

Starting valve (faulty solenoid)

The starting valve does not open during ignition and the excess fuel being directed to the engine may cause a high t4 temperature peak.

Micro-pump

Faulty operation of the motor : there is no fuel pressure building up, no rise in t4 temperature, and starting is not possible. It is worthy of note that the fuel cock light does not go "on".

Microswitch jammed in working position :the fuel cock opens before the proper time, this risks to cause a high t4 temperature. It is worthy of mention that the yellow light goes "on" before the proper time. At stopping, the fuel cock may close slower by reason of the circuit being established by the micro-pump contact jammed at work.

Microswitch jammed in resting position : there is a slight rise in t4 due to the igniters, but no fuel cock opening and consequently impossible starting. It is worthy of mention that the yellow light does not go "on".

Electric fuel cock

"Opening" contact faulty : there is no fuel cock opening, and consequently, starting is not possible. It is worthy of mention that the light goes "on" and that there is a slight rise in t4 due to the igniters (the yellow light goes "on" but does not go "out").

"Supply to T5 a" contact faulty : The T5 a does not operate and the ignition accessories remain operating, the t4 risks to be very high and the yellow light remains illuminated.

"Closing" contact faulty : engine normal stopping is not possible.

"Supply to T5 r" contact faulty : after engine stopping, no resetting of the electric system, the blockage light remains "on" and the next starting is not possible.

Starter cut-out switch

Resting contact faulty : no starter, the green light does not go "on".

Working contact faulty : no direct supply to the time-delay switch T 30, relay "m" is cut-out only by a MF (i.e. during acceleration).

Short-circuit between moving contact and resting contact: at self-sustaining speed, the supply to starter relay is held, the relay "a" second shunt is not established and when the T 30 operates, there is engine stopping.

Short-circuit between moving contact and working contact : The T 30 is directly supplied at the very beginning of starting and a few seconds later, the starting cycle is cut-out.

Starter relay

Main contact faulty : the starter does not operate, nevertheless, the green light goes "on".

Main contact jammed in working position : no starter cut-out at self-sustaining speed, the relay "a" second shunt is not established and the cycle is interrupted at T 30 action (moreover, the starter is continuously set under power).

Auxiliary resting contact faulty : the relay "a" second shunt is not established at self-sustaining speed, and the cycle is interrupted at T 30 action.

Microswitches

MF microswitches

Working contact faulty : no supply to relay "m" when power is set on the system, the blockage light goes "on", starting is not possible.

Moving contact jammed at work : starting is possible even if the lever is not fully closed.

MO microswitches

Moving contact jammed in closed position : no safety preventing engine stopping when the lever is opened.

Moving contact jammed in opened position : no supply to the relays when power is set on the system, starting is not possible.

MPO microswitch

Moving contact jammed in closed position : the light indicating the lever position remains illuminated even when the lever is fully opened.

Moving contact jammed in opened position : no indication of position of the lever.

Starter switch

Ventilation contact (d) faulty

No ventilation sequence

Starting contact (a) faulty

No ignition sequence during starting

Starting contact (d) faulty

No starter during starting sequence.

Components of the control box

Relay "a" faulty

Normal stop of engine is not possible.

Relay "m" faulty

No starting and no ventilation

Time-delay switch T5 a faulty

There is no cut-out of the ignition sequence and risk of overheating.

Time-delay switch T5 r faulty

No resetting of T5 after engine stopping, the next start is not possible.

Time-delay switch T 30 faulty

There is no limitation safety of the startingtime.

Diode faulty

Risk of deterioration of the time-delay switch T5 r.

Working contact nr 1 of the relay "m" faulty (m 1 t)

The relay "a" first shunt cannot be established and the ignition sequence does not take place, starting is not possible.

PRACTICAL WORKS

Practical works on the electric system incorporate the following practices.

Removal, installation and check of the accessories

Works quoted in various chapters.

Replacement of the complete automatic control box

Replacement of the starter relay

Removal, disassembly, check, assembly, installation.

Replacement of the moving block

Disassembly and assembly of the electric plug

Insulation check

Continuity check

Connection and utilization of the fuel cock control box

Indication of operation by means of the simulator

- connection
- handling
- fault finding.

Note

The essential part of the practical works lies in fault finding by means of the simulator.

UTILIZATION OF THE SIMULATOR

The simulator permits to check the operation of the automatic control box.

Nevertheless, during a training course, it is essentially used for training purposes.

The practices include :

- connection of the simulator
- handling
- fault finding and fault analysis.

Connection of the simulator

This operation consists in connecting the simulator box, the automatic control box and the supply source.

Handling

This practice consists in handling the simulator and in checking the operation.

Fault finding and fault analysis

This practice consists in :

- observing the symptoms of the fault by handling the simulator
- analysing the various symptoms
- finding the cause of the fault by indicating the reasons leading to this conclusion.
- repairing the fault if need be.

Operating instructions

A - Tools

Simulator Ref. 21401000

Adapting electric wiring Ref. 214 20 700.

B - Preparation for the test

Disconnect the electric plugs of the micro-pump, of the coil, of the electric fuel cock, of the lever stop contactor and of the pressure switch.

Disconnect the plugs C 3 (8Y) and D 1 (9Y) of the box to be checked.

Pull out the battery from its housing.

Place the simulator on a step-ladder near the aircraft.

Connect the adapting electric wiring to the plug F of the simulator.

Connect the moving plugs of the accessories to the corresponding plugs of the simulator ; these plugs are marked with the following letters :

A - micro-pump
B - coil
C - electric fuel cock
F - lever stop
M - pressure switch.

Connect to the box the moving plugs 8Y and 9Y of the simulator.

Disconnect from the starter-generator the starter supply cable.

On the simulator, put downwards the switches "24 volts" and "ignition pressure" and the change over switches "self-sustaining speed" and lever half-opened - "lever closed", and make sure that the circuit-breaker is cut-out and that the change over switch "start-stop-ventilate" is to "stop".

Hook the "starter" clamp of the simulator on the clip of the starter cable.

Hook the earth clamp of the simulator on the bonding braid of the control box.

Connect the battery to the simulator, be careful in respecting the polarity.

Engage the circuit-breaker of the simulator.

NOTA : Two parts can be found in the simulator :

- on the left, indication of instruments in the cockpit (on pilot's side)
- on the right, indication of supply to turbine ancillaries (on turbine side).

Note

During a training course, the procedure is carried out in the class-room and with a supply source of stabilized direct current.

C - Ventilation tests

PROCEDURE	CORRESPONDING INDICATIONS	
	PILOT'S SIDE	TURBINE SIDE
Place the switch 24 V upwards		The red light "fuel cock closed" goes "on"
Place the change over switch "start-stop-ventilate" on "ventilate" and hold it	The "starter" green light goes "on"	The "starter" white light goes "on"
After about 30 seconds	The "starter" green light goes "out" and the "blockage" red light goes "on"	The "starter" white light goes "out"
Release the change over switch "start-stop-ventilate" which comes back to "stop"	The "blockage" red light goes "out"	
Wait during at least 1 minute before the next test		

D - Start and stop test

Place the change over switch "start-stop-ventilate" to "start"	The "starter" green light goes "on"	The "starter", "coil", "micro-pump" and "booster pump" white lights go "on" The "fuel cock closed" red light is still "on"

About 2 seconds later, place the switch "ignition pressure" upwards	The "fuel cock" yellow light goes "on"	The "fuel cock closed" red light goes "out" The "fuel cock opened" green light goes "on"
About 3 seconds later	The "fuel cock" yellow light goes "out"	The "coil" and "micro-pump" white lights go "out"
About 5 seconds later place the change over switch "self-sustaining speed" upwards	The "starter" green light goes "out"	The "starter" white light goes "out"
About 2 to 5 seconds later		The "booster pump" white light goes "out"
Wait about 1 minute and place the change over switch "start-stop-ventilate" to "stop"	The "blockage" red light goes "on"	The "fuel cock opened" green light goes "out" and the "fuel cock closed" red light goes "on"
16 to 18 seconds later	The "blockage" red light goes "out"	
Place the change over switch "self-sustaining speed" and the switch "ignition pressure" downwards		
Place the switch 24 V downwards		
Release the circuit-breaker		The "fuel cock closed" red light goes "out"

E - Re-setting in operating condition

Disconnect the battery from the simulator.

Unhook the earth clamp of the simulator from the bonding braid of the box.

Unhook the "starter" clamp of the simulator from the clip of the starter cable.

Connect the starter supply cable to the starter-generator.

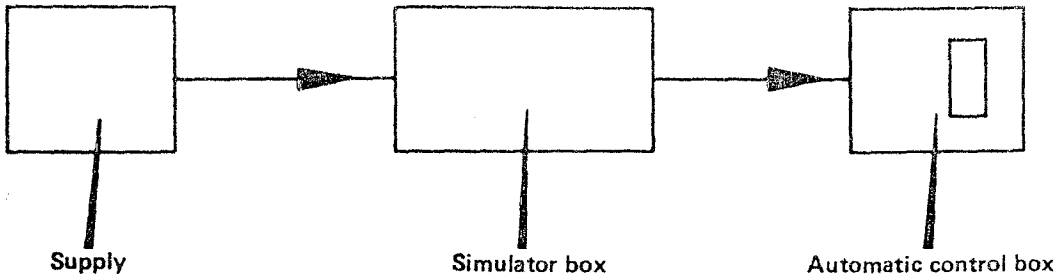
Disconnect from the control box the moving plugs of the simulator 8Y and 9Y.

Disconnect the moving plugs A B C F M and connect them to the accessories : micro-pump, coil, electric fuel cock, lever stop, pressure switch.

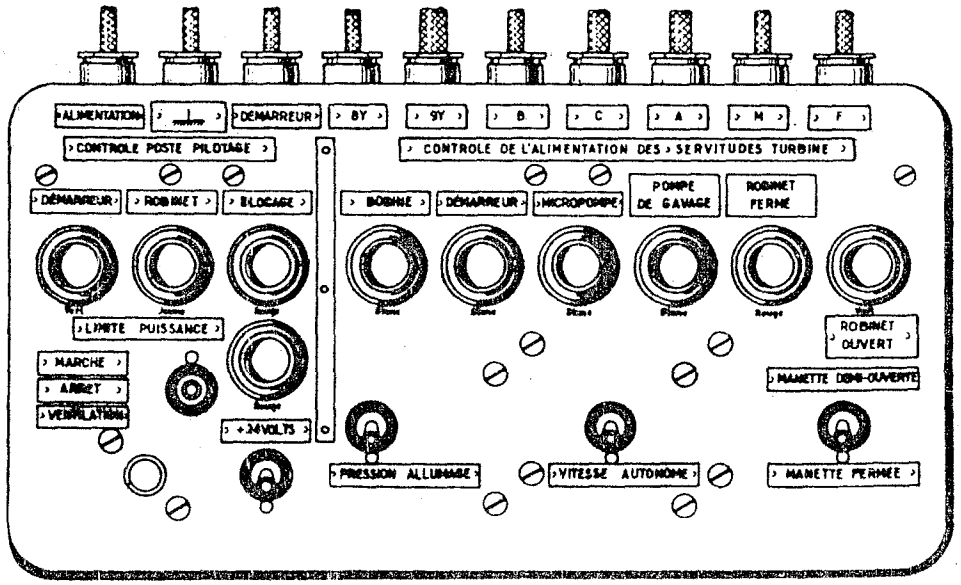
Place the simulator in its box.

Place the battery in its housing.

Connect the plugs C 3 (8Y) and D 1 (9Y) to the control box.



SCHEMATIC DIAGRAM OF CHECK SYSTEM LAY OUT



SIMULATOR BOX EXTERNAL VIEW

NOTES

CHAPTER 13

MAINTENANCE

- OPERATING INSTRUCTIONS AND CURRENT MAINTENANCE
- MAINTENANCE PROCESS : Procedures, Checks, Maintenance work
- ADJUSTMENTS
- FAULT ANALYSIS
- CHARACTERISTICS AND LIMITATIONS
- LIST OF MATERIALS
- PRACTICAL WORK
- GENERAL OVERHAUL ASPECT
- MISCELLANEOUS INFORMATION

OPERATING INSTRUCTIONS AND CURRENT MAINTENANCE

PRE-FLIGHT INSPECTION

Aircraft checks concerning the power plant

- Battery checking
- Checking of fuel filter clogging indicator
- Checking of the booster pump operation
- Tank draining (water draining)
- Checking of lubricating oil level

Checks on the power plant

- Checking of the front attachment
- Checking of accessory attachment
- Checking of the free movement of the control lever
- Checking of pipes and unions
- Checking for leaks
- Checking of the free rotation of the rotating assembly
- Checking of the locks
- Checking of the external casings

PERIODIC INSPECTION

- Inspection of the oil filter (replacement of the cartridge)
- Oil system draining (only when operating with mineral oil)
- Sampling of oil and dilution measure
- Inspection of the turbine casing drain
- Inspection of the air intake and 1st stage compressor
- Inspection of 3rd stage turbine and exhaust pipe (jet pipe, diffuser collar, turbine)
- Inspection of the starter-generator
- Checking of condition and operation of the igniters
- Inspection of the P2 air tapping filter
- Checking of the thermocouple condition
- Checking of external parts for corrosion
- Carry out all the check-out procedures of the previous pre-flight inspection
- Make a ground-run test.

Note

The above procedures are given for training purposes only. They are only typical inspections and the official manuals should be consulted about the accurate frequency and details of practices.

TIME BETWEEN OVERHAUL (T.B.O.)

Same operating time between overhaul for accessories and engine.

CHECKS AND TESTS DURING OPERATION

Before starting

- Carry out a pre-flight inspection
- Check and note the battery voltage
- Check and note residual t 4 temperature

During starting :

Check and note :

- the battery voltage drop
- the t 4 temperature
- the starting cycle (lights, ignition time)
- the starting duration
- the rotation speed at starter cut-out
- the oil pressure and temperature
- the idling speed

During acceleration (from idling speed to max. rotation speed)

Check and note :

- the t 4 temperature
- the beginning of fuel flow control
- the acceleration duration
- the full opening of the lever.

At nominal rotation speed

- Check the rotation speed value
- Check the t 4 temperature
- Check the oil pressure and temperature
- Carry out a booster pump cut-out test.

During power variations

- Check the variation of rotation speed and the time required to restore the nominal speed in transient condition.
- Check the t 4 temperature (in stabilized and transient condition.)
- Check the oil pressure and temperature.

During stopping (normal stopping on ground)

- Check the idling speed (engine warm)
- Check the stopping cycle (light)
- Check the run-down time
- Check the resetting time.

ENGINE TEST SHEET

"Example"

ENGINE - ARTOUSTE III nr _____ Date _____

TEST BENCH or AIRCRAFT nr _____ Po _____ To _____

STARTING

Battery static voltage _____ residual t4 _____ Safety test ____

Start _____ Ignition _____ Ignition "off" _____

Max. t4 _____ Battery voltage drop _____

Starter cut-out _____ N _____ time _____

Idling _____ N _____ time _____

Oil pressure _____ Oil temperature _____ t4 _____

ACCELERATION (from idling to lever full opening)

Acceleration time _____ t4 _____

Beginning of fuel flow control _____ α lever _____ ΔN _____

Max. speed _____ N _____ Oil pressure _____ Oil t° _____ t4 ____

POWER VARIATION

Transient condition _____ Time _____ ΔN _____ Δ t _____ t4 _____

Stabilized condition _____ Pitch _____ N _____ t4 _____

Transient condition _____ Time _____ ΔN _____ Δ t _____ t4 _____

STOPPING

Deceleration _____ Oil pressure _____ t4 _____

Idling _____ N _____ t4 _____ Oil pressure _____ Oil t° _____

Run-down _____ Resetting _____

REMARKS

NAME _____ SIGNATURE _____

PARTICULAR CONDITIONS OF OPERATION

Operation in salty atmosphere

- Carry out frequent inspections for corrosion on the engine external parts (pay special attention to the casings made of light alloy).

- Apply the external corrosion matter on the places where corrosion occurs (AIR 1502).

- Increase the frequency of the periodic inspections and of the inhibiting procedures.

- Apply the treatment meant for protection of the air duct (especially the compressor) against corrosion (refer to compressor rinsing and fiel cleaning).

Operation in sandy atmosphere

- Install the filtering assembly on engine air intake (provided by aircraft manufacturer).

- Carry out the required inspections on the air intake filter.

- Carry out "frequent" inspections of the air intake and compressor condition (axial wheel).

- Increase the frequency of periodic inspections.

- Apply the treatment of compressor field cleaning in case of fouling of the air duct.

Operation in "cold" atmosphere

- Make sure that there is de-icing fluid in the pipe of the P2 pressure switch (t° lower than 0° C).

- Pay special attention to the condition of the battery.

- Check the oil temperature and respect limitations.

ENGINE INHIBITING PROCEDURE

In case of non operation beyond a certain time, the engine must be protected against the corrosion agents.

The most efficient protection consists in filling the fuel system and the engine with a special mixture and in placing the engine in a pressurized container.

The maintenance manual gives all informations concerning the instructions to be followed according to the duration of engine non operation and its position.

The operating instructions for fuel system inhibiting are the following :

- Disconnect the engine fuel inlet pipe
- Connect the inhibiting tank : fill it up with the special fuel-oil mixture
- Disconnect the coil electric plug (and booster pump plug)
- Disconnect the pipe from micro-pump to 4-way union and mount a jet.
- Control the starting sequence
- Spray the inhibiting mixture in the air intake
- Move the fuel control valve lever
- Stop the procedure (not more than 15 sec.) and make sure that the mixture flows through the turbine casing drain pipe.
- Blank-off all orifices.

The operating instructions for de-inhibiting are the same but it must be carried out with fuel. Do not forget to carry out a ventilation after the procedure.

EXTERNAL PROTECTION AGAINST CORROSION

In service, the protecting coat applied at the factory may have partially disappeared.

In this case, it is recommended to apply a slight preventive coat (with a brush) of an external protecting matter corresponding to the standard AIR 1 502.

Note

It is not necessary to make a general applying with a spray-gun when sending the engine back to the factory.

COMPRESSOR FIELD CLEANING

Two types of procedure must be considered :

- Protection
- Cleaning.

PROTECTION

The protection procedure includes " a rinsing procedure " and a protecting procedure.

CLEANING

Cleaning of compressor and air duct includes : "washing procedure", "rinsing procedure", and "protecting procedure".

The principle is to spray a special mixture in the air intake during an engine ventilation or during operation at idling speed.

Note

Refer to the Maintenance Manual for procedure details.

RINSING OF THE OIL SYSTEM

The purpose of the procedure is to clean (rinse) the engine lubricating system. It must be carried out, for instance, when the oil standard is changed (from mineral oil to synthetic oil or vice-versa).

Schematically, the operation instructions are as follows :

- Draining of the system (engine warm)
- Filter cleaning
- Partial filling (with new oil of required standard)
- Ground run (to obtain an increase in oil temperature)
- Draining
- Replacement of the cartridge
- Full filling
- Ground run test
- Check for leaks
- Oil level check.

Note

The purpose of the above statement is to "have the procedure understood" rather than describe it in full details.

Refer to the maintenance manual for further information.

ENGINE OIL DRAINING AND FILLING

The draining of the system is carried out through a plug at the lower part of the oil tank.

The oil cooler also is provided with a drain plug and the oil of the engine front section can be drained through a plug located at the lower part of the accessory casing.

Being given that the tank does not belong to the engine manufacturer the procedure of draining and filling is to be described by the aircraft manufacturer.

CLEANING OF THE FUEL INJECTION WHEEL

The purpose of the procedure is to clean the jets of the injection wheel when they are clogged by carbonization of the fuel.

The "cleaning" procedure is carried out by means of a special set of tools which include a "cleaning rod" and an endoscopic instrument.

The endoscopic device allows the lighting of the combustion chamber internal part and the rod allows the cleaning of the jets.

The bosses of the turbine casing are used for the passage of the cleaning rod and the endoscopic device.

A source of air pressure must be connected to the engine fuel inlet during the procedure.

When the cleaning rod is inserted, it is advisable to make sure that it penetrates completely into the jet (the jets have two different diameters).

It is required to mark the jets in order to make sure that they have all been cleaned.

Note

The fuel injection wheel clogging (a partial clogging of course) is expressed by rotation speed oscillations and incorrect fuel flow control characteristics (eg. jerk around yawing axis in power variation).

CHECKING OF THE FUEL SYSTEM SEALING

With engine running

- Carry out a complete cleaning of accessories and pipes
- During a ground run, check for leaks :
  - on mating surfaces,
  - on connections,
  - on pipes.
- The same check-out procedure can be carried out for the other systems.

With engine stopped

- Carry out a complete cleaning of accessories and pipes
- Open the electric fuel cock (see simulated start procedure)
- Operate the booster pump
- Move the control lever
- "Carefully" check for leaks
- In case of leaks, locate the component having a faulty sealing and replace or repair it
- Do not forget to carry out a "ventilation" after this procedure
- Carry out a ground run test.

ROTATION SPEED INDICATION

To obtain a rotation speed more accurate than the one given by the aircraft instrument, it is possible to use :

- either an electronic tachometer connected to the tachometer transmitter of the engine ;
- or a mechanical tachometer connected to the spare drive on upper train of accessory drive.

It is thus possible to check the accuracy of the aircraft system (by comparison) and to obtain an accurate indication of the speed (nominal speed adjustment on isochronous speed governor).

Note

Do not forget to take into consideration the reduction ratio of the drive when reading on the mechanical tachometer.

INDICATION OF THE ROTATION SPEED OSCILLATIONS

The rotation speed oscillations are expressed by air pressure fluctuations at P2 compressor outlet. It is then possible to obtain an indication of the "oscillations" by measuring the P2 air pressure.

The check-out procedure consists in connecting a calibrated pressure gauge to a boss of the turbine casing and in observing the hand of the pressure gauge during a ground run.

This procedure is particularly used to adjust the speed governor isochronous scroll.

INDICATION OF THE OIL PRESSURE

The lubricating oil system is provided with "pressure tapping points".

It is possible to connect a calibrated pressure gauge to one of the "pressure tapping points" and to check the oil pressure during an engine ground run.

The union used to check the pressure is on the nut of the oil pressure transmitter.

A special union allows the mounting of the pipe connected to the pressure gauge.

Make sure of the pressure gauge calibration before carrying out the checking. This check-out procedure is used to adjust oil pressure.

CHECKING OF THE COMBUSTION CHAMBER DRAINING

It is possible to check by admitting compressed air into the drain pipe.

Another mean consists in putting the finger at the end of the drain pipe when the engine is running ; the compressed air must be felt.

In case of clogging of the drain, remove and clear it.

CHECKING OF ENGINE POWER

This check-out procedure is defined by the aircraft manufacturer. It uses the law relating the t4 temperature, the helicopter rotor pitch, and the atmospheric temperature.

It is carried out in stationary flight with ground effect by watching the t4, the pitch and the temperature, and by comparing with the curve affected with a correction factor.

Refer to aircraft manufacturer's manual to obtain more details about this procedure.

CHECKING OF THE "FREE ROTATION" OF THE ROTATING ASSEMBLY

The check-out procedure consists in turning the rotating assembly by hand in both directions and in making sure that there are no abnormal noises or abnormal frictions.

It is possible to turn the rotating assembly by hand on the axial compressor through the air intake or on the turbine third stage through the exhaust diffuser.

The "ventilation" procedure (as well as the "run-down time" measure) allows also the checking of the free rotation.

CHECKING OF THE AXIAL WHEEL CONDITION

It is possible to check by visual inspection of the axial compressor blades condition through the air intake casing.

The maintenance manual incorporates the criteria of acceptation in case of wear or cracks or distortions.

CHECKING OF THE 3rd STAGE TURBINE WHEEL CONDITION

It is necessary to remove the exhaust pipe to inspect carefully the 3rd stage turbine blades.

Carefully see that there is no deposit, impacts, overheating marks, rubbing.

Refer to maintenance manual for criteria of acceptation.

INSPECTION OF THE EXHAUST DIFFUSER

The purpose of the visual inspection is to detect the possible cracks.

The sole acceptable cracks are those on the welding of the attachment pads of the arms.

The maintenance manual incorporates the criteria of acceptation as well as the welding methods.

TURBINE REAR BEARING CHECKS

On removal and installation of the rear bearing, it is necessary to check :

- the condition of the bearing components
- the free movement of the bearing
- the oil circulation after installation.

These procedures are dealt with in full details during practical works.

STARTER-GENERATOR CHECKS

The checks include :

- brushes and collector wear check
- insulation check under 45 V.

These procedures are dealt with in full details during practical works.

CHECKING OF THE THERMOCOUPLES

The checking includes :

- checking of the condition of the thermocouples
- checking of the loop (d = 3 $\pm$ 0.4 mm)
- insulation check (higher than 50,000 Ω under 45 V)
- continuity check.

VIBRATION CHECK

Requires a special installation which is only used optionally by the engine manufacturer.

CHECKING OF THE STARTING ACCESSORIES

Introduction

The simple watching of the indicating instruments must allow the checking of the operation of the various accessories.

The checking may also be carried out by the method of "simulated start" as well as by means of a special set of tools.

Checking of the operation of micro-pump and fuel cock (checking by the method of simulated start)

- Disconnect the supply to starter
- Disconnect the supply to ignition coil
- Carry out a start
- Check the micro-pump operation (operating "noise", yellow light)
- Check the operation of fuel cock opening (operating "noise", visual indicator, yellow light)
- Check the ignition time (T5a, yellow light)
- Carry out engine stopping
- Check the operation of fuel cock closing ("noise", visual indicator, blockage light)
- Check the resetting time (T5r, blockage light).

Checking of starting valve operation (simulated start)

- Carry out a simulated start as indicated to check the micro-pump
- Check the operation of the starting valve
  - operating noise
  - visual observation of the draining.

Checking of the four-way union (simulated start)

- Disconnect the outlet union to P2 tapping
- Carry out a simulated start
- Check the sealing of the four-way union ball
  - check for possible fuel leak through the disconnected union.

Note

Do not forget to carry out a ventilation after these check-out procedures.

Checking of igniter spraying (simulated start)

- Disconnect the supply to starter
- Disconnect the supply to ignition coil
- Remove the igniters from turbine casing
- Connect again the supply pipe to the igniters
- Carry out engine "starting"
- Check the spraying (igniters in open air)
    - spraying quality
    - spraying angle (min. 25°, max. 35° from the longitudinal axis).

Checking of igniter sparks (simulated start)

- Disconnect the supply to starter
- Disconnect the supply to micro-pump (electric plug)
- Remove the igniters from turbine casing
- Connect again the coil supply to the igniters
- Carry out engine "starting"
- Check the sparks at the end of igniters (the spark must be produced between the electrodes and of blue color).

Note

No need to put the igniters to earth.

Checking of ignition coil (simulated start)

- Disconnect the supply to starter
- Disconnect the supply to micro-pump (electric plug)
- Connect a "test" igniter at the coil HT outlet
- Carry out engine "starting"
- Check the quality of sparks at the end of the "test" igniter
- Carry out the same procedure for the second coil.

Note

Being given that the operation of the "test" igniter has been ascertained, it is thus possible to check the coil operation.

NOTE

Make sure of the connections before initiating this check-out procedure by simulated start.

Do not forget to carry out a ventilation before setting in operating condition.

Checking of the starter circuit (simulated start)

- Disconnect the electric supply to micro-pump
- Disconnect the supply to ignition coil
- Carry out engine "starting"
- Check : - the green light
  - the increase in speed.

- If the green light remains "out", check the starter cut-out switch

- If the green light goes "on" and the starter does not rotate
  - check the starter relay
  - check the starter motor.

Checking of fuel cock and micro-pump by means of the control box

- Connect the control box to micro-pump and fuel cock
- Connect the current supply source
- Control the box
- Check micro-pump and fuel cock operation.

Checking of the automatic control box by means of the "simulator" box

- Connect the simulator
- Connect the current supply source
- Initiate the simulation procedure
- Check the operation by means of the indicating lights.

Note

The check-out procedure by means of the simulator is covered in a paragraph of the chapter "Electric system" and in practical works during a training course.

MAINTENANCE WORKS

By "maintenance works", it is to be understood :

- the various procedures
- the check-out procedures
- the procedures of removal and installation
- the procedures and assembly and disassembly.

During a training course, these procedures are covered in practical works on the engine.

This paragraph merely gives the list of "removal-installation" and "disassembly-assembly" procedures.

Removal and installation

All the accessories

Disassembly and assembly

- Turbine rear bearing
- Output shaft seal
- Jet-holder
- Combustion chamber drain
- Oil filter
- Oil pump pressure relief valve
- P2 air tapping filter
- Four-way union ball
- Fuel pump shaft seal
- Fuel pump pressure relief valve
- Fuel pump by-pass
- Speed governor isochronous scroll
- Electric fuel cock rotating valve
- P2 pressure switch
- Starter-generator seal
- Automatic control box
- Starter relay
- Automatic control box moving block.

ADJUSTMENTS

OIL PRESSURE ADJUSTMENT

- Make sure of an accurate oil pressure indication - Connection of a calibrated pressure gauge on the provided pressure tapping on the oil filter (see oil pressure check-out procedure).

- Make sure of the pressure relief valve correct operation . The valve can be removed and checked without disturbing the adjustment.

- Carry out the pressure check with a suitable oil temperature (40° to 60° C).

- Carry out the adjustment (possible with engine running) by acting on the adjusting screw of the oil pressure relief valve.

- Proceed slowly by fractions of a turn. 1/2 turn = 0.4 b. Screw in to increase the pressure.

Note

Let us recall that the pressure must be : higher than 0.8 b at idling speed and between 1.4 and 5 bars at maximum rotation speed.

MICRO-PUMP PRESSURE ADJUSTMENT

- Make sure of a micro-pump pressure indication. Connection of a calibrated pressure gauge at micro-pump outlet.

- Initiate micro-pump operation (see simulated start procedures allowing the operation of the micro-pump only).

- Carry out the adjustment by acting on the adjusting screw of the micro-pump pressure relief valve - Screw in to increase pressure.

Note

This adjustment is not forbidden, but it is unlikely to be undertaken being given that most of micro-pump faults are not due to the adjustment itself.

ADJUSTMENT OF THE FUEL PUMP BY-PASS (starting t4)

- This adjustment permits to determine the fuel flow at the beginning of starting, that is, the t4 gas temperature.

- The adjustment consists in changing the passage section of the pump by-pass jet ; this change is obtained by replacing the jet.

- Before replacing the by-pass, make sure that the abnormal temperature is not due to some other fault.

- Note the accurate moment of starting phase when the temperature is abnormal (the by-pass effect is especially felt at the beginning of starting).

- Check for by-pass obstruction

- Carry out the by-pass jet replacement by means of a special screw-driver.

- Increase the passage section to decrease the pump fuel flow i.e. decrease the t4 temperature.

- Carry out a test and take notice of the modification.

- Do not forget that the by-pass replacement is possible within certain limits only. min. : 0.8 mm - max. : 1.1 mm.

STARTING VALVE ADJUSTMENT (starting t4)

- This adjustment permits to determine the fuel flow towards the injection wheel during the ignition phase, i.e. the t4 temperature at beginning of starting (t4 peak).

- This adjustment consists in changing the draining overboard through the starting valve.

- Before initiating the adjustment check the operation of the electro-valve and make sure of the non-obstruction of the air vent.

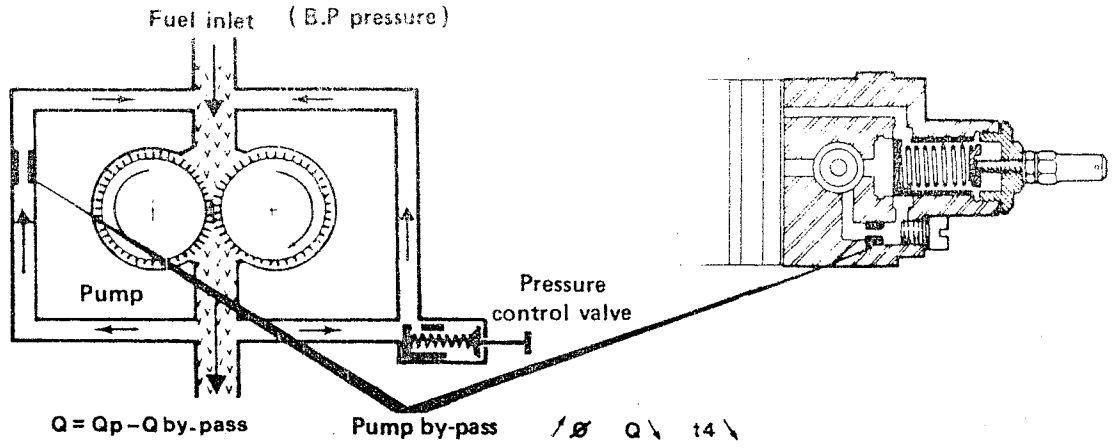
- Act on the adjusting screw of the electro-valve. Screw in to decrease the spilling, i.e. the t4 during ignition.

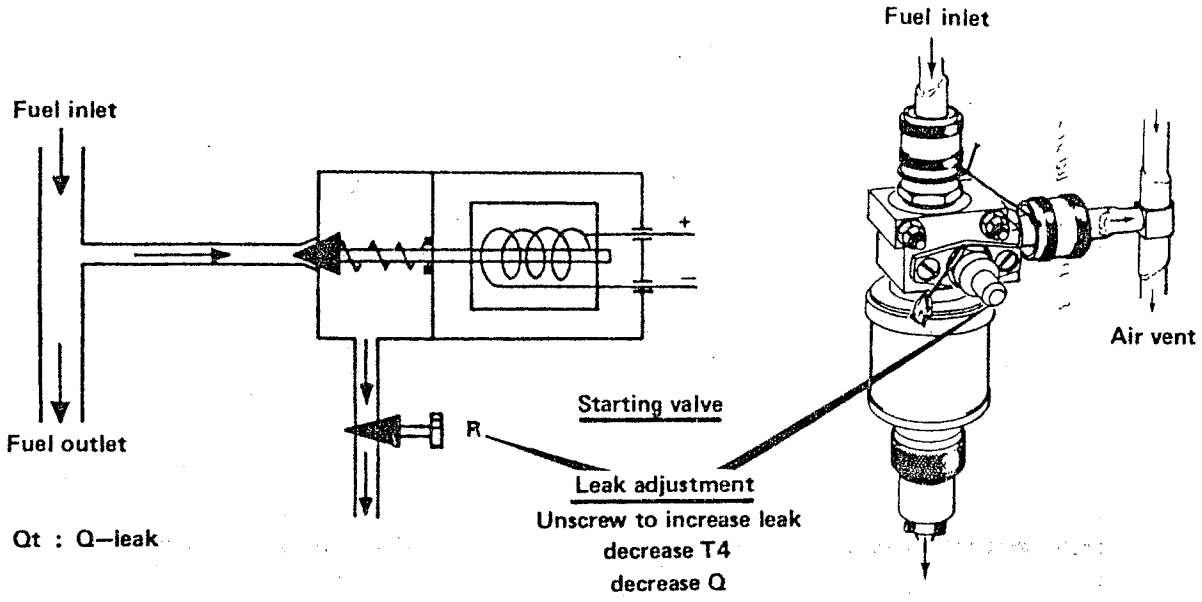
- Carry out a test and take notice of the change.

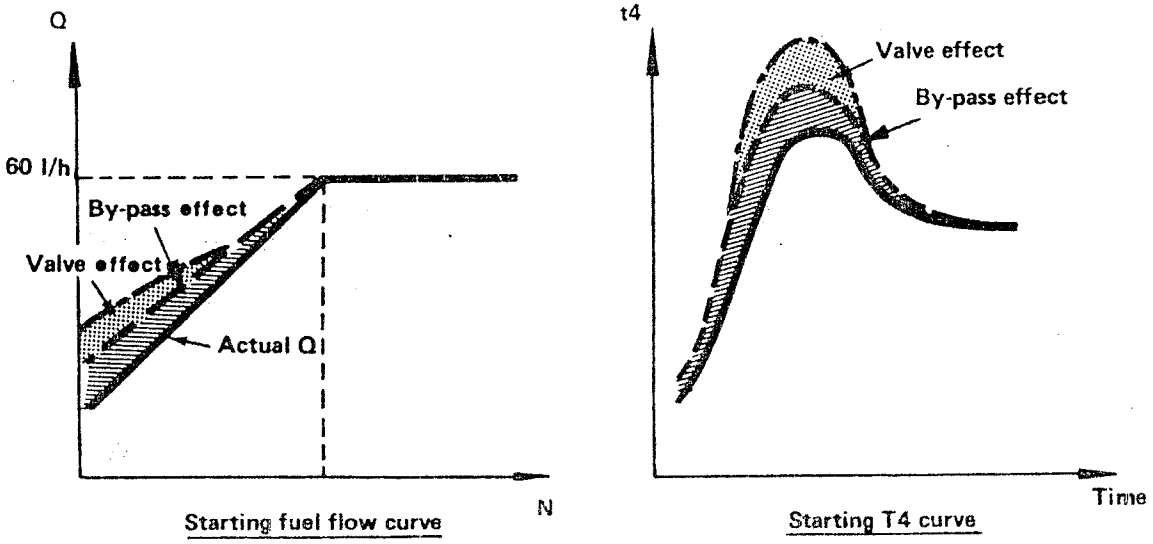
Note

Let us recall that the max. t4 peak during starting is of 600° C during 2 to 3 seconds and 630° C max.

The adjustment must allow the obtaining of a correct starting speed ; i.e. a quick starting with an acceptable temperature.







STARTING T4 — ADJUSTMENTS

ADJUSTMENT OF THE STARTING DEVICE (idling adjustment)

- The starting device adjustment allows the modification of the idling rotation speed.

- Before carrying out the adjustment, make sure of the non-obstruction of the device metering valve.

- If the adjustment is required by a difficulty to start, begin increasing the fuel flow by screwing down the adjusting screw of one or two fractions of a turn (ball locking every 1/6 of turn).

- Carry out a start

- Check the idling speed indication (engine "warm" and stabilized condition).

- Act on the capsule adjusting screw. By screwing in the fuel flow is decreased, i.e. the speed.

Note

The idling rotation speed must be comprised between 15,000 and 19,000 RPM.

The starting device meters the fuel flow in function of the Po atmospheric pressure. The action on the adjusting screw changes, not only a point, but also the whole curve flow/Po. As the device affects the starting fuel flow as well as the idling fuel flow, it is most important to make sure of the operation in all conditions of Po.

ADJUSTMENT OF THE STARTER CUT-OUT SWITCH

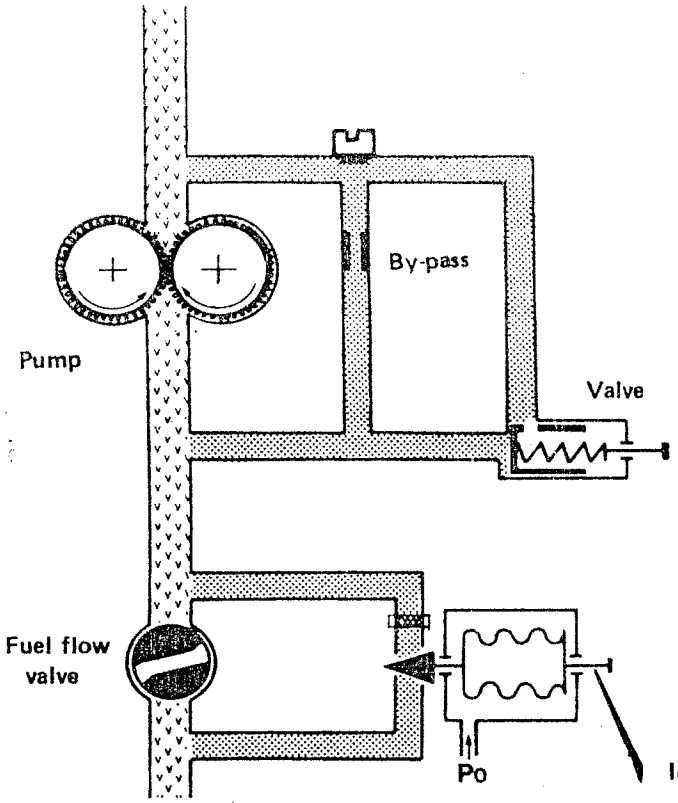
This adjustment is only applied to the pressure switch controlled by the fuel pressure.

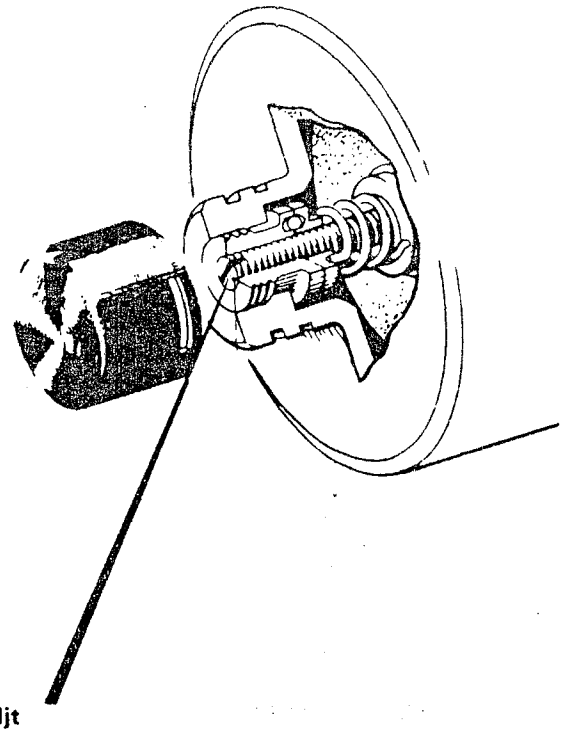
The adjustment allows the modification of the pressure switch setting, i.e. the rotation speed at starter cut-out.

Act on the adjusting screw to obtain the cut-out at the required rotation speed. Screw down to decrease the rotation speed.

Note

The rotation speed at starter cut-out should be the following : 14,000 RPM $\pm$ 1,000 RPM.

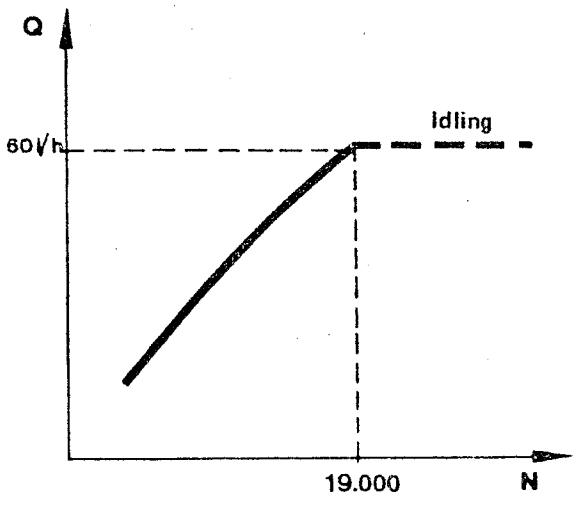




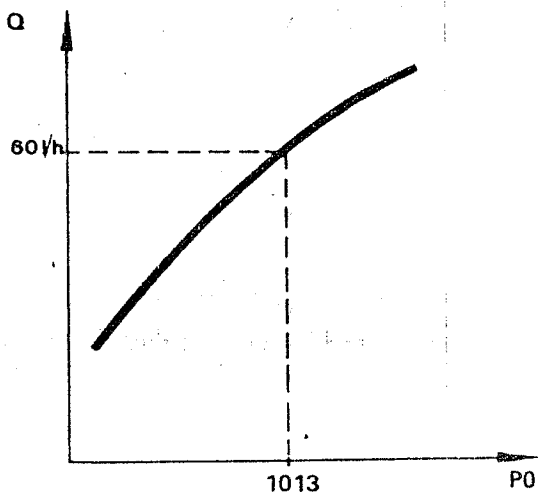
Idling Q : f (Po)

Screw in to decrease idling

SCHEMATIC DIAGRAM OF THE IDLING DEVICE



Starting fuel flow curve



Po – Fuel flow curve

IDLING DEVICE ADJUSTMENT

ROTATION SPEED ADJUSTMENT

- Make sure of an accurate indication of the rotation speed.

Installation of a tachometer on the spare drive.

- Make sure of the lever full opening and of the speed governor "taking over" for the checking.

- Carry out the adjustment on the tension screw of the speed governor opposing spring. The adjustment can be made with engine running.

- Adjust in the following way : unlock the lock nut, act on the adjusting screw. Screw in to increase the rotation speed.

Note

The nominal (or max.) rotation speed must be : 33,500 ± 200 RPM, on the tachometer between 7,917 and 8012 RPM.

When the lock nut has been unscrewed, do not pull out the screw driver from the slot of the adjusting screw because the screw might be drawn back by the opposing spring of the speed governor, which might cause an overspeed.

ADJUSTMENT OF THE ISOCHRONOUS SCROLL

- This adjustment determines the speed governor characteristics. It must be carried out particularly in case of rotation speed oscillations.

- Make sure that the rotation speed oscillations are not caused by any other fault than one of the isochronous scroll.

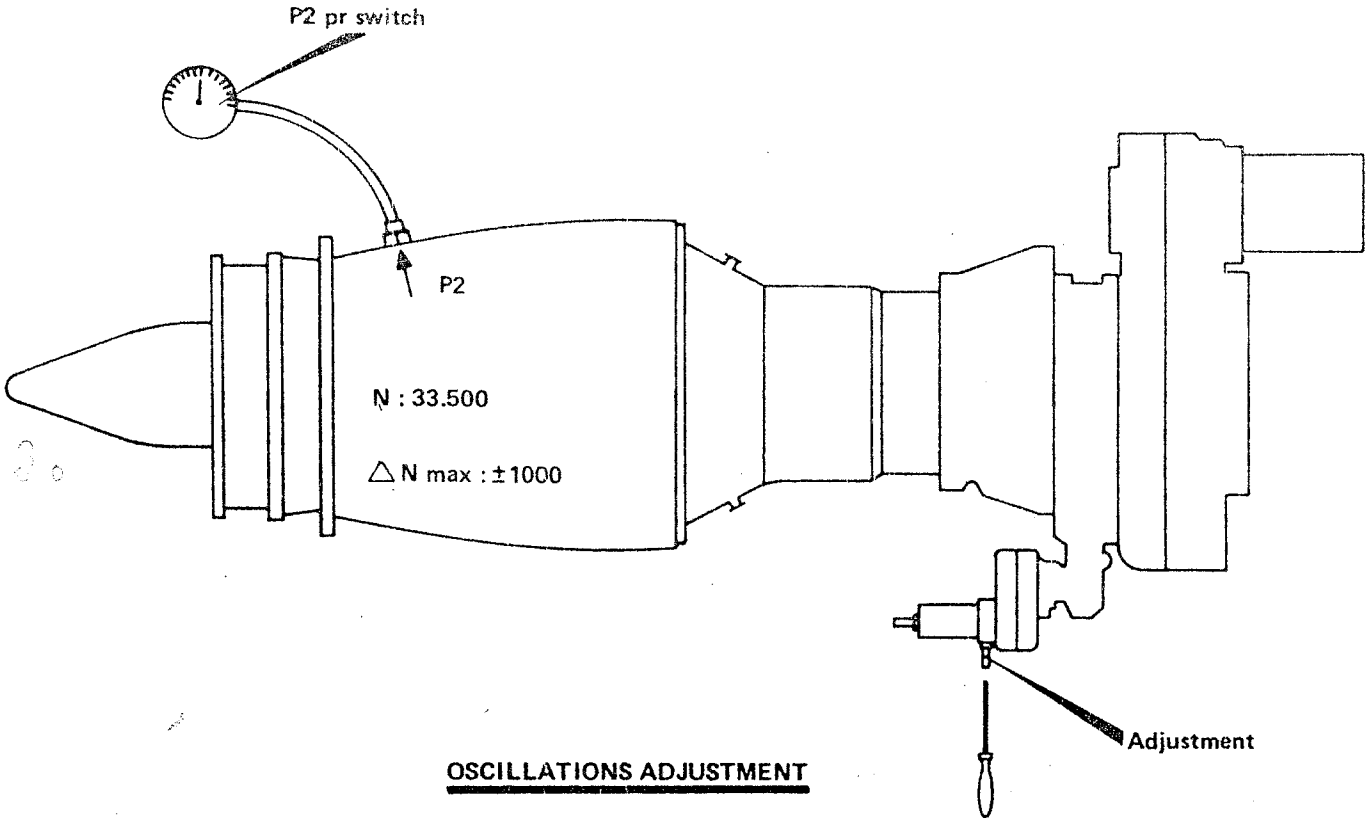
- Make sure that the isochronous scroll is not clogged. It is possible to carry out this check by disassembling the scroll without disturbing the adjustment.

- Make sure of an accurate rotation speed indication. Tachometer or connection of a pressure gauge to a P2 air tapping.

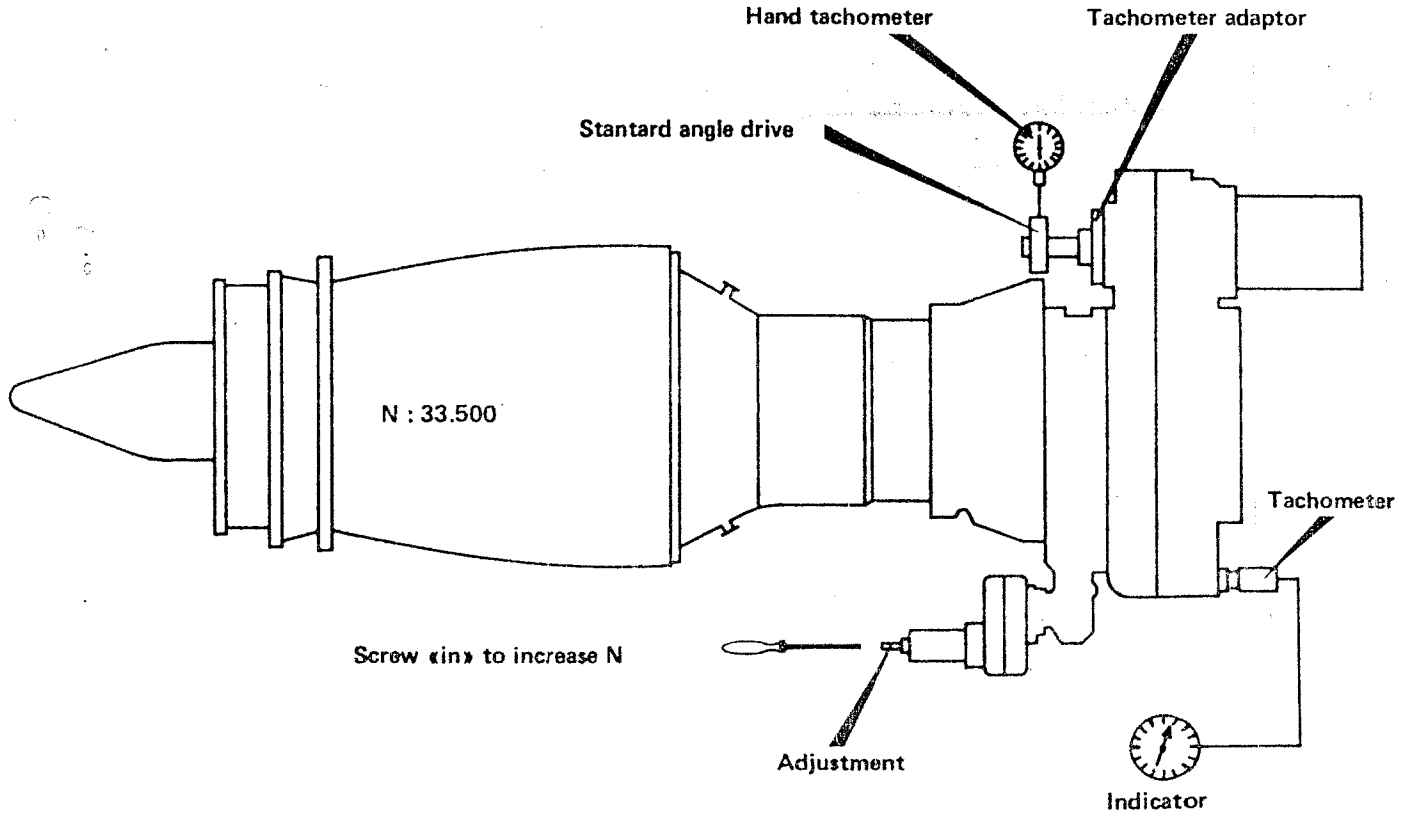
- Carry out the adjustment (possible with engine running) by acting on the isochronous scroll adjusting screw. Unscrew until the pressure gauge hand indicates slight fluctuations (the engine is then very sensitive to the load and unstable). As soon as the fluctuations appear, screw in the adjusting screw, very progressively, up to stability.

Note

Let us recall the speed governor characteristics : complete stability and no oscillations in stabilized load condition, speed variation lower than 1,000 RPM in transient condition, time required for restoration of stable nominal rotation speed very fast (lower than 4 seconds).



OSCILLATIONS ADJUSTMENT



ROTATION SPEED ADJUSTMENT

OTHER ADJUSTMENTS

Fuel pump pressure adjustment

Forbidden in field maintenance

Speed governor minimum fuel flow adjustment

Forbidden in field maintenance

T5 a time-delay switch adjustment

Forbidden in field maintenance

T5 r time-delay switch adjustment

Forbidden in field maintenance

T30 time-delay switch adjustment

Forbidden in field maintenance

Setting of the microswitches

See aircraft manufacturer's manual

t4 line resistance adjustment

See aircraft manufacturer's manual

Fuel flow valve control adjustment

See aircraft manufacturer's adjustment.

FAULT ANALYSIS

INTRODUCTION

The fault analysis is also dealt with in the study of the various engine components (refer to various chapters). This analysis is carried out from the cause of the fault, up to its effect(s).

This chapter also deals with the faults of operation, but according to the reverse process ; i.e. from the effects, up to the most likely causes.

PRESENCE OF FUEL IN OIL

Sensing

The presence of fuel in lubricating oil can be detected by the following means :

- oil level increasing
- typical smell from the oil tank
- change in oil density
- measure of the flash point (laboratory).

Dilution limit

The maximum dilution ratio allowed is 10 % during 25 running hours.

Possibilities of passage of fuel into oil

- Fuel pump drive shaft seal
- Jet-holder ("flexibox" seal)
- Speed governor (sealing of metering valve and casings)
- Internal channels (porosity of the casings).

Note

It is a valuable indication to check the jet-holder draining in order to make sure of the good sealing of the jet-holder seals.

ABNORMAL OIL PRESSURE

By "abnormal" it must be understood : either too low a pressure, or too high a pressure, or pressure fluctuations.

Let us note the most likely causes :

- Pressure indication (oil pressure indicating system)
- Incorrect oil level
- Oil not in compliance with the specification required
- Abnormal oil temperature
- Oil filter clogging
- Pump pressure relief valve failure
- Oil internal pipe or line clogging
- Oil pump deterioration.

Note

A "local" defect in lubrication is not necessarily expressed by an abnormal oil pressure.

ABNORMAL OIL TEMPERATURE

By "abnormal" oil temperature, it must be understood a temperature which is beyond the limits permitted.

The most likely causes are :

- Wrong indication
- Oil cooler failure
- Oil cooler valve faulty operation
- Oil not in compliance with the specification required
- Engine local overheating.

ABNORMAL OIL CONSUMPTION

In the case of non-consumption or of too low a consumption, let us recall that the fuel may have gone into oil.

In the case of too high a consumption, there is then an internal or external oil leak.

A few cases of external oil leaks

- Turbine rear bearing (paper gasket and labyrinth seal). The leak is expressed by smoke coming from the exhaust diffuser.

- Output shaft seal ("sealol" type seal). The oil leak occurs in the clutch.

- Starter drive shaft seal ("Simrit" type seal). The leak is expressed by an external leak and passage of oil into the starter (do not forget to clean the starter).

- Tachometer transmitter drive shaft seal ("Simrit" type seal) External leak and passage of oil into the tachometer transmitter.

- Oil system accessories - Leak at the mating surfaces and on attachment points of the system accessories.

- Pipes, unions, seals

Cases of internal leaks

- Axial compressor front bearing seal ("Sealol" type seal) The leak may be expressed by "tracks" in the air intake casing. Moreover, the oil goes through the engine gas vein.

- Axial compressor rear bearing seal ("Sealol" type seal) The oil goes through the engine gas vein. Oil vapours can be emitted in the aircraft manufacturer's P2 air tapping point.

- Centrifugal compressor bearing seal ("Sealol" type seal) The oil goes through the gas vein and oil vapours can also be emitted in P2 air.

- Jet-holder oil seal ("Sealol" type seal). Oil leak in the draining pipe of the jet-holder and possibility of passage of fuel into oil.

FOAMING IN THE OIL TANK

Let us quote the most likely causes :

- Incorrect oil level (too high a level reduces the expansion volume of the tank).

- Oil not in accordance with specification.

- Too high an oil temperature.

- "Breathers" clogged and air entering the system.

- Tank put under pressure (this is possible in case of faulty sealing of the engine intermediate bearings "Sealol" seals).

CASE OF OPERATION WITH A PRODUCT NOT IN ACCORDANCE WITH SPECIFICATION

If the lubricating "product" is not in accordance with the specification , deteriorations may result in engine or in accessories.

In the case when this faulty operation is diagnosed "in time", it is necessary to carry out the rinsing procedure of the oil system and to check the condition and the operation of the system.

Let us recall that it is forbidden to mix synthetic and mineral oil, and that it is advisable not to mix synthetic oils of different trade marks.

EFFECT OF OIL CHARACTERISTICS ON FUEL FLOW CONTROL

The isochronous speed governor is operated with lubricating oil.

Any failure in oil supply is then expressed by a faulty operation of the speed governor. (It is particularly worthy of note that there is a risk of overspeed in the case of non supply with oil to the speed governor. It is also worth to mention the case of underspeed likely to happen in the case of air entering the speed governor oil system. Careful bleeding of the speed governor through the damper scroll is then recommended).

ABNORMAL t4 TEMPERATURE

During starting

The most frequent causes are :

- t4 indicating system
- Battery voltage
- Starting device (or idling device)
- Fuel pump by-pass
- Four-way union ball
- Faulty sealing of the system.

Other causes

- Torch-igniters
- Ignition coil
- Electric fuel cock sealing
- Micro-pump microswitch
- Ignition time
- Combustion chamber drain valve
- Starter.

During acceleration (from idling to max. N)

- Too fast an acceleration
- Fuel pump pressure relief valve jammed.

During normal operation

- t4 indicating system
- Wrong pitch indication
- Compressor dirty or deteriorated
- Engine internal failure.

Attention

Special attention to :

- Battery voltage
- Fuel pump by-pass
- Starting device.

Note

Each point named needs a comment ; refer to corresponding chapter for details.

ROTATION SPEED OSCILLATIONS

- Tachometer indicating system
- Faulty sealing of the fuel system (air entering the system)
- Receiver balance (helicopter rotor)
- Faulty operation of the speed governor
- Partial clogging of the fuel injection wheel.

ENGINE POWER DROP

- Fuel flow control defect
- Important P2 air leak
- Compressor dirty
- Compressor deteriorated
- Engine internal failure (combustion chamber, turbines).

ENGINE OVERSPEED

- Too fast a power variation (transient)
- Fuel flow control defect
- Faulty oil supply to the speed governor.

Note

Above a certain speed, the engine should be replaced in order to carry out a general overhaul.

COMPRESSOR SURGING

During starting

- Too fast a speed acceleration
- Compressor deterioration.

During normal operation

- Max. power override
- Too fast a power variation
- Fuel flow control defect
- Compressor dirty
- Compressor deteriorated
- Engine internal deterioration.

Note

Each point quoted should be commented.

ENGINE FLAME OUT (UNEXPECTED STOPPING)

- Unexpected fuel cut-out (the electric fuel cock closing is nevertheless practically impossible)
- Faulty fuel supply (fuel pump drive shaft rupture for instance)
- Air entering the fuel system
- Want of fuel
- Water or ice ingestion.

ABNORMAL VIBRATIONS

- Faulty balance of the receiver (helicopter rotor)
- Engine attachment
- Fuel flow control defect
- Deterioration of the bearings
- Internal failure.

ABNORMAL FRICTION OF THE ROTATING ASSEMBLY

Can be detected by turning the engine with hand in both directions, and by measuring the run-down time at engine stopping.

The following causes can be noted :

- Accessories (seizing of an engine driven accessory)
- Turbine blades creeping
- Reduction gear failure.

Note

If the abnormal friction does not come from an accessory or from the rear bearing, the engine should be replaced.

"ABNORMAL"NOISES

The engine "noises" are difficult to be described. Thus, we shall merely quote :

- "Saw" noise (coming from a labyrinth touching the rotating assembly)
- "Touch" noise (coming from the turbine blades touching the casing)
- Accessory noise (starter-generator carbons for instance).

Note

Try to determine if the abnormal noise comes from an accessory. If it does not come from an accessory (or from the turbine bearing), the engine should be replaced.

STARTING FAULTS (ELECTRICAL CAUSES)

This paragraph deals only with the most typical cases and only mentions the most likely causes.

When electric power is set on the system : illumination of the blockage light.

Cause : MF microswitch.

On switching to "start" : no starter, no green light.

Cause : starter cut-out switch (resting contact).

On switching to "start": no starter, but green light "on".

Cause : starter relay, starter motor.

On switching to "start" : no rise in t4, no yellow light.

Cause : micro-pump.

On switching to "start" : yellow light, but no rise in t4.

Cause : ignition coil.

On switching to "start" : yellow light goes immediately "on"

Cause : micro-pump microswitch (jammed at work).

During starting : the light goes "on" and remains "on"
the t4 does not rise
no flame ignition

Cause : failure in fuel cock opening (limit-switch).

During starting : the light goes "on" and remains "on"
the t4 rises (high t4)

Cause : no action of T5 a (fuel cock limit-switch).

During starting : starting cycle interrupted 2 to 3 seconds after switching

The blockage light goes "on"

Cause : short-circuit in the starter cut-out switch.

During starting : the green light does not go "out" at self-sustaining speed

Cause : starter cut-out switch.

At the end of starting : the engine stops 2 to 3 seconds after self-sustaining speed

Cause : second shunt of the relay "a" (auxiliary contact of the starter relay).

At the end of starting : the engine stops 50 to 60 seconds after switching

Cause : starter cut-out switch (working contact).

During acceleration : the engine stops when the lever is displaced
illumination of blockage light

Cause : starter cut-out switch ; control box.

Note

Do not forget the influence of the characteristics of the current source on the electric components operation during engine starting.

Too low a supply voltage may lead to difficulties in starting, and especially too high a temperature of the exhaust gases.

STARTING FAULTS (MECHANICAL CAUSES)

This paragraph deals only with the most typical cases and mentions only the most likely causes.

During starting : normal electric cycle
difficult ignition
low t4, especially at beginning of starting

Cause : starting valve (too important a draining)
pump by-pass (too great ⌀)
booster pump (too low pressure)

During starting : normal electric cycle
high t4 at beginning of starting

Cause : starting valve (insufficient or nil draining)
pump by-pass (too small ⌀)

During starting : normal electric cycle
high t4 during the whole cycle
quick acceleration

Cause : pump by-pass (too small ⌀)

At the end of starting : normal electric cycle
high t4
too high idling speed

Cause : idling device (too high adjustment of fuel flow)

At the end of starting : normal electric cycle
low t4
slow acceleration
too low idling speed

Cause : idling device (too low adjustment of fuel flow)

During acceleration : too high a rise in t4 at displacement of the lever

Cause : fuel pump pressure relief valve.

STOPPING FAULTS (ELECTRICAL CAUSES)

On switching to "stop" : no yellow light flash
no illumination of blockage light
no engine stopping

Cause : MO microswitch
Electric fuel cock (limit-switch)

On switching to "stop" : the blockage light remains "on"

Cause : no resetting through T5r (incorrect next starting)
electric fuel cock limit-switch.

STOPPING FAULTS (MECHANICAL CAUSES)

On switching to "stop" : normal electric cycle
no engine stopping

Cause : electric fuel cock faulty sealing

On engine stopping : too low a run-down time
noises

Cause : abnormal friction
engine accessories (seizure - hard point)
rear bearing (deterioration, free movement)
turbine creeping (blade touch).

Note

This fault analysis is not exhaustive and a comment is required for each point mentioned. It must be especially used for training purposes.

CHARACTERISTICS AND LIMITATIONS

INTRODUCTION

The purpose of this paragraph is to group in a few pages all the turbo-shaft characteristics and values.

Nevertheless, it is worthy of mention that, in the limits of the instruction manual, they are valid for information only.

MAIN PERFORMANCES

Nominal performances in standard atmosphere at take-off rating.

- Shaft power ..... W = 405 kw (550 ch)
- Fuel specific consumption ..... Cs = 0.469 kg/kw/h
  0.345 kg/Cv/h
- Residual thrust ..... Pr = 43.4 daN (44.2 kg)
- Engine weight ..... 182.500 kg $\pm$ 3 %

Note

The power of 405 kw (550 cv) can be taken up to an altitude of 4,200 metres (or at altitude 0 up to a temperature of 45° C).

MAIN LIMITATIONS

- Rotation speed

  Nominal speed ..... N = 33,500 RPM $\pm$ 200

  Max. variation in transient condition ..... N = $\pm$ 1,000 RPM

- t4 gas temperature

  Max. temperature ..... t4 = 550° C

  Max. continuous temperature ..... t4 = 500° C

  Max. temperature at starting ..... t4 = 630° C

- Oil

  Pressure : Min. pressure : 1.4 b
  Max. pressure : 5 b

  Temperature : Min. temperature : 0° C
  Max. temperature : 85° C

GAS GENERATOR CHARACTERISTICS

Shaft power	W = 405 kw (550 cv)
Rotation speed	N = 33,500 RPM
Turbine inlet temperature	t3 = 700° C
Air flow	G = 4.5 kg/sec.
Compression ratio	P2/Po = 5.2
Compressor efficiency	η = 0.759
Turbine efficiency	η = 0.862
Gas exhaust velocity	V = 95.2 m/sec.
Residual thrust	Pr = 43.4 daN (44.2 kg)
Equivalent power	Weq = 433 kw (589 cv)
Specific consumption	Cs = 0.469 kg/kw/h 0.345 kg/cv/h

ROTATION SPEEDS

Nominal speed	N = 33,500 RPM
Output shaft speed	N = 5,773 RPM
Idling speed	N = 15,000 to 19,000 RPM
Speed at starter cut-out	N = 14,000 RPM $\pm$ 1,000
Variation of max. N in transient condition	Δ N = $\pm$ 1,000 RPM
Max. overspeed limit	N = 35,500 RPM
Speed at the end of ignition	N = about 6,000 RPM
Speed at MO action	N = about 28,000 RPM
Rotation speed in ventilation	N = about 5,000 RPM.

TEMPERATURES

Air temperature at axial outlet	t1' = 60° C
Air temperature at centrifugal outlet	t2 = 250° C
Gas temperature at turbine inlet	t3 = 700° C
Gas temperature at turbine outlet	t4 = (according to rating)
Maximum t4	550° C
Maximum continuous t4	500° C
Max. t4 at starting	600° C 2 to 3 sec.
Max. t4 at starting(upper limit)	630° C
t4 during acceleration	t4 50° C
Max. residual t4 before starting	175° C

LUBRICATION

Oil specification : mineral	AIR 3515
synthetic	AIR 3513
Oil volume	7 l
Usable volume	
Drainable volume	
Max. consumption	0.4 kg/h
Oil pressure at idling speed	0.8 b
Min. oil pressure at max. speed	1.4 b
Max. oil pressure	5 b
Min. oil temperature (before applying W).....	+10° C
Max. oil temperature	mineral oil : 75° C synthetic oil : 85° C
Max. fuel dilution	10 % in 25 hours.

FUEL SYSTEM AND FUEL FLOW CONTROL

Fuel specification	AIR 3405 AIR 3407
Booster pump pressure	0,5 b
Booster pump fuel flow	
Aircraft filter filtering power	
Micro-pump pressure	4 b
Micro-pump fuel flow	20 l/h (with igniters)
Main pump pressure	8 b
Pump by-pass	
Idling fuel flow	60 l/h
Starter cut-out switch setting	0,39 b
Min. fuel flow	
Max. fuel flow	
Pump rotation speed	SIH N/10,370
Speed governor rotation speed	N 8,89
Speed governor pump pressure	about 8 b
Nominal governed speed	33,500 $\pm$ 200 RPM
Speed variation in transient condition	$\pm$ 1,000 RPM
Time required for stabilized condition restoration	$<$4 sec.

AIR SYSTEM

P2 air pressure	5.2
P2 air temperature	about 250° C
Engine air flow	4.5 kg/sec.
Taken air flow	80 g/s
Effect of air taking	0.5 kw/gr/
P2 pressure switch setting	0.4 b

ENGINE CONTROL AND INDICATION

MF microswitch setting	0°
MO microswitch setting	Half travel N=26,800
MPO microswitch setting	Full opening
t4 line resistance	16Ω
Insulation of thermocouples	>50000Ω

ELECTRIC SYSTEM

Supply voltage	28 v
Accessory operating voltage	14 to 30 v
Battery min. voltage for starting	25.5 v
Voltage drop during starting	14 v minimum
Starter-generator	4 kw - 850 A max.
Insulation	>500,000Ω under 45 v
T5a time-delay switch	3.5 to 4 sec. } under constant 24 v
T5r time-delay switch	16 to 20 sec. } under constant 24 v
T30 time-delay switch	50 to 60 sec. } under constant 24 v
Thermocouples	insulation >50,000Ω under 45 v loop : d= 3± 0.4 mm

TIMES

Max. starting time ..... 50 to 60 sec.

Ignition time ..... 5 to 15 sec.

Time required for micro-pump pressure building up ..... 1/2 sec.

Fuel cock opening (or closing) time ..... 3/4 sec.

T5a time-delay switch (under constant tension) ..... 3 to 4 sec.

Resetting time ..... 16 to 20 sec.

Run-down time at stopping ..... 45 sec.

Ventilation time ..... 15 sec.

Ventilation limitation ..... 50 to 60 sec.

Waiting time after 3 false starts ..... 20 minutes.

MISCELLANEOUS

Reduction ratio

- reduction gear ..... SIH N/5.8025
- starter-generator ..... SIH N/10.370
- tachometer transmitter .... SIH N/10
- oil pump ..... SIH N/10.370
- fuel pump ..... SIH N/10.370
- speed governor ..... SIH N/8.889
- spare drive ..... SIH N/4.206

Tightening torque

- rear bearing nut ..... 10 m/kg
- output shaft nut ..... 10 m/kg

Dimensions

- overall length ..... 1,805.3 mm
- overall width ..... 520 mm
- overall height ..... 627 mm

Weight

- Weight of power plant equipped : 182 kg.

MAINTENANCE

Operating time between overhaul .....

Frequency of periodic inspections .....

Accessory T.B.O. .....

Maintenance time per flight hour .....

General overhaul cost .....

Cost of standard exchange of engine .....

ADJUSTMENTS

Oil pressure adjustment

Micro-pump pressure adjustment

Pump by-pass adjustment

Starting valve adjustment

Idling device adjustment

Starter cut-out switch setting

Nominal rotation speed adjustment

Isochronous scroll adjustment.

LIST OF MATERIALS

FUELS

The fuels used are indicated below

A = Aircraft fuels (see notes 1 and 2)

SPECIFICATIONS			
French	American	English	N.A.T.O.
AIR 3405 (TRO)		D.Eng. RD 2482 issue 3	F 30 F 34
AIR 3407A(TR4)	MIL J 5624 E (JP4)	D.Eng. RD 2486 issue 3 Am 1	F 40
AIR 3404A(TR5)		D.Eng. RD 2488 issue 3	F 42
(see note 1)	MIL J 5624 E (JP5)	D.Eng. RD 2493 issue 1	F 44
Essence AIR 3401 G (see note 2)	MIL G 5572 C	D.Eng. RD 2485 issue 3 Am 1	F 12 F 15 F 18 F 22

B = Navy fuels (see note 3)

SPECIFICATIONS			
French	American	English	N.A.T.O.
95 STM - 47/O DIESO (see note 3)	MIL F 16 884 C type 1 or 2		F 75

C = Other fuels (see notes 2, 4 and 5)

SPECIFICATIONS			
French	American	English	N.A.T.O.
Essence autochars (tank fuel) DCEA/2 CMT 80 (see note 2)	MIL G 3056 A	ST 501 18	F 46
Pétrole lampant (see note 4)	illuminating oil (kerosene)	illuminating oil (kerosene)	
Gas oil routier (see note 5)	Automotive diesel oil	Automotive diesel oil	

NOTE 1 - The fuels in accordance with the French specification AIR 3404 A and with their foreign corresponding specifications can be used only if their density is lower than 0.8.

NOTE 2 - The fuels in accordance with the French specifications AIR 3401 G and DCEA/2C MT 80 and with their foreign corresponding specifications must only be used during a maximum of 25 hours between overhauls. It is advisable to add 1 % of lubricating oil to the fuel.

NOTE 3 - The fuels in accordance with the French specification 95 STM 47/0 DIESO and with their foreign corresponding specifications must not be used at a temperature lower than - 15° C.

NOTE 4 - The fuel in accordance with the French name "Pétrole lampant" (illuminating oil) and its foreign corresponding fuels must have the following specifications :

- sulphur lower than 0.2 %
- flash point higher than 38° C
- freezing point lower than - 40° C.

NOTE 5 - The "gas oil routier" (automotive diesel oil) and its foreign corresponding specifications must have the following characteristics and must not be used below 0° C.

- sulphur lower than 1%
- kinematic viscosity at 20° C lower than 9 centistokes.

OILS These oils are in accordance with the following specifications :

SPECIFICATIONS		
French	American	English
AIR 3515	See NOTE 1	D. Eng. RD 2490 Am 1
AIR 3513	MIL. L. 7808 Am 1 C, D or E see NOTE 2	

NOTE 1 - In case of want of the American specification corresponding to the French and English standards, use one of the oils :

- Aeroshell turbine Oil 3
- Esso Aviation Utility Oil F
- Caltex Jet engine oil medium heavy

or a similar oil, after engine manufacturer's agreement.

NOTE 2 - Index C : corresponds to the oil commonly used
Index D and E : concern only the inhibiting qualities of oil.

MIXTURE FOR FUEL SYSTEM INHIBITING

9 parts of fuel (AIR 3405, AIR 3407 or 3404)

1 part of oil AIR 3515.

MIXTURE FOR COMPRESSOR CLEANING

Washing

Water + Methanol

Protection

Ardrox

Cleansing

Ardrox
Kerosene
Methanol
Water

Rinsing

Water + methanol

EXTERNAL PROTECTION AGAINST CORROSION

Product AIR 1502

INTERNAL PROTECTION AGAINST CORROSION

Product AIR 1504 or AIR 3515

CLEANING OF METALLIC PARTS

White spirit

CLEANING OF METALLIC PARTS (NOT PAINTED)

Trichloretylene.

DE-ICING FLUID FOR P2 PRESSURE GAUGE PIPE

Glycol S 750.

ANTI-ICING PRODUCT FOR MICRO-PUMP MICROSWITCH

Silicon vaseline "Compound S i 4"

PENETRATING PRODUCT

To remove hot parts (TRANSYL).

ANTI-SEIZING PRODUCTS (mounting of warm parts)

Grease with a high melting point - AIR 4247 - AIR 4223.

SEALING PRODUCT

Jointing compound SQ 32 M or SQ 32 L.

MOUNTING GREASE

AIR 4225 or tallow - Pure mineral vaseline AIR 3565

GRINDING PRODUCT

Abrasive powder - Abrasive paper - "India" stone - Sulphur flower.

PRACTICAL WORKS

INTRODUCTION

During a training course, the practical works carried out on the engine incorporate :

- maintenance procedures
- check-out procedures
- adjustments
- removal and installation practices.

This paragraph gives the list of all these practices.

PROCEDURES

1 - Pre-flight inspection
2 - Periodic inspection
3 - Engine inhibiting
4 - Protection against corrosion
5 - Compressor field cleaning
6 - Oil system rinsing
7 - Oil draining and replenishing.
8 - Injection wheel cleaning §

CHECK-OUT PROCEDURES

9 Checking of fuel system sealing
10 Rotation speed indication §
11 Rotation speed oscillation indication §
12 Oil pressure indication §
13 Checking of combustion chamber draining
14 Checking of power
15 Checking of the free rotation of the rotating assembly.

16 Checking of axial wheel condition

17 Checking of turbine 3rd stage

18 Checking of exhaust diffuser

19 Checking of turbine rear bearing

20 Checking of starter-generator
- -wear of the brushes
- -insulation

21 Checking of thermocouples
- condition
- insulation
- continuity

22 Checking of vibrations

23 Checking of starting accessories
- simulated start
- control box
- simulator.

ADJUSTMENTS

24 Oil pressure adjustment §

25 Micro-pump pressure adjustment

26 Fuel pump by-pass adjustment §

27 Idling speed adjustment §

28 Starting valve adjustment §

29 Rotation speed adjustment §

30 Rotation speed oscillations adjustment. §

INSTALLATION AND REMOVAL PROCEDURES

31 Removal and installation of accessories (all the accessories)

32 Turbine rear bearing §

33 Output shaft seal §

34 Jet-holder (is permitted in field maintenance only after engine manufacturer's previous agreement)

35 Combustion chamber drain

36 Oil filter

37 Oil pump pressure relief valve

38 P2 air tapping filter §

39 4-way union ball

40 Micro-pump shaft seal

41 Fuel pump seal

42 Fuel pump by-pass §

43 Fuel pump pressure relief valve

44 Speed governor isochronous scroll §

45 Electric fuel cock rotating valve

46 Starter cut-out switch §

47 Starter-generator seal

48 Automatic control box .

49 Starter relay

50 Automatic control box moving block.

Note

- Certain operations of practical works can only be "simulated".

- The operations marked with a § offer a special interest and should absolutely be performed.

- Each practice is carried out with a work card used as a guide.

GENERAL OVERHAUL ASPECT

INTRODUCTION

The "general overhaul" is a process which is carried out when the engine reaches the end of its T.B.O. ; i.e. after a determined number of running hours.

The purpose of this process is to reintroduce the engine into service for a new T.B.O.

The overhaul process involves a whole range of practices which are carried out in a "station" or overhaul workshop.

TYPICAL PROCESS OF A GENERAL OVERHAUL

The "general overhaul" includes a series of practices which are carried out according to the following scheme :

Receipt

This practice incorporates the "unpacking" of the engine from its container and a first inspection.

Disassembly

This practice includes the removal of all the accessories and the engine disassembly.

The various components are placed on transport trolleys and dispatched towards the various workshops. The components are divided in engine components on one side and in accessories on the other side.

Cleaning

Each component should be carefully cleaned in order to allow an efficient inspection.

The process uses cleaning methods by bath, sand-blasting ...

Inspection

This practice consists in checking the condition of the various components. The inspection incorporates :

- the detection of cracks and structure faults (magnetic detection, detection by sweating, micrography...)
- the inspection of the bearings
- the inspection of pipes
- the metallurgic tests ("Vickers" hardness test, "Brinnel" hardness test...)
- the dimension check
- the balancing.

Investigation - This practice consists in taking advantage of the results of the inspection procedure and in deciding whether the components are to be rejected or used again, as well as the repairs or modifications which are to be introduced.

Surface treatment

Treatments of metallic surfaces such as : chromium plating, cadmium plating, and chemical treatments such as : anodisation, parkerisation ... and painting of the parts.

Reworks

The required reworks of the parts involve various methods such as :

- welding (electric, with argon...)
- drilling
- milling
- rectifying
- fitting.

After this reworking practice, the part is inspected again and investigated.

Accessories

The engine accessories (electric and hydraulic accessories) are also subjected to the process of : disassembly, cleaning, checking, assembly and various tests.

Installation

All the parts which have been subjected to the overhaul process are re-installed and the accessories are secured on the engine.

Test bench

The overhauled engine is subjected to a series of tests allowing the checking of the performances and their operation.

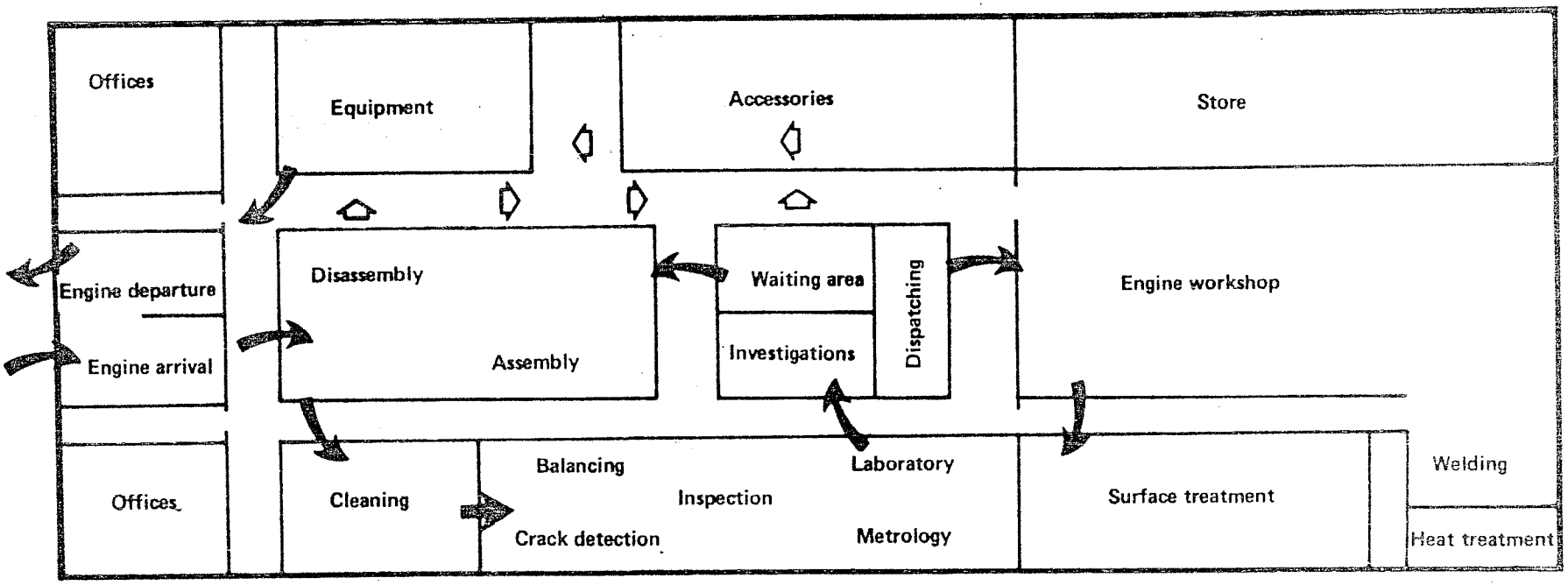
Inhibiting

The engine is inhibited, placed in a container and, if required, delivered to the customer.

Documentation

The general overhaul forms the subject of a documentation sent to the operators (reports, log book, amendment...).

GENERAL OVERHAUL WORKSHOP



LEGEND

Engine parts circuit

Accessories circuit

MISCELLANEOUS INFORMATION

INTRODUCTION

The purpose of this paragraph is to give information about various technical questions in relation with the life of the material.

T.B.O. (time between overhaul)

The T.B.O. is the time of engine operation between general overhaul. It is determined by the engine manufacturer by common agreement with official services and the operator.

GENERAL OVERHAUL

It is the overhaul practice which is carried out at the end of the T.B.O. and which permits to put the engine in service for another T.B.O.

I.R.A.N. (inspect and repair as necessary)

It is an optional partial overhaul which permits to reintroduce the engine into service without changing the T.B.O.

RELIABILITY

It is the probability of operation without the failure of a device in determined conditions and for a defined duration.

MTBF: Mean time between failure.

MODIFICATION

All the modifications brought to the material are classified according to the process of application and degree of urgency.

The modifications can be optional, recommended or compulsory. Any modification is followed by an information sent to the operators and of an amendment of engine documentation.

MATERIAL MONITORING

The "material monitoring" by computer enables to carry out a permanent control of the life of engines.

At the level of the operator, the directions are obtained by means of the reports RAP 01, 02 and 03. A copy of each of these reports is given in the following pages.

DOCUMENTATION

An engine forms the subject of various publications which are listed below :

- Engine drawings set
- Maintenance manual
- Overhaul manual (acceptance test book)
- Operating manual
- Special Tool Catalogue
- Spare parts catalogue
- Illustrated Parts Catalogue
- Log book
- Engine form
- Monthly report
- Trouble report
- Various reports
- Turbomeca Service Bulletin
- Technical instruction
- Service letter.

REMARKS

All remarks (criticism, suggestions, appreciations...) must be forwarded to "TURBOMECA TRAINING SERVICE" 40 / TARNOS.

REMARKS REGARDING THE MANUAL

REMARKS REGARDING THE COURSE

NAME :

Address :

Course from ..... to .....

NOTES

QUESTIONS

INTRODUCTION

This paragraph contains a list of questions which may be "considered" in a course.

The answers to these questions can be found in the various chapters of this manual. The questionnaire is arranged according to the same plan as the manual.

GAS TURBINE ENGINE GENERAL

1 - Name the main sections of a gas turbine engine.

2 - Explain the need for a high compression ratio in a gas turbine engine.

3 - Which are the main parameters characterizing the operation of a compressor ?

4 - Advantages and disadvantages of the centrifugal compressor and of the axial compressor.

5 - Explain the phenomenon of surging in a compressor.

6 - Purpose of the primary air and of the secondary air in a combustion chamber.

7 - What are the advantages of the centrifugal fuel injection ?

8 - Purpose of the turbine in a turbo-jet engine.

9 - Purpose of the turbine in a turbo-shaft engine.

10 - Explain the phenomenon of creeping of the turbine blades.

11 - Explain the need (and the importance) of turbine inlet temperature limitation and distribution.

12 - What is the meaning of equivalent power in a turbo-shaft engine ?

13 - What is the meaning of fuel specific consumption ?

14 - Advantages and disadvantages of the free turbine compared with a fixed type turbine.

15 - What are the effects of atmospheric temperature on the performances of a turbo-shaft engine ?

16 - What are the effects of altitude on the performances of a turbo-shaft engine ?

ARTOUSTE III GENERAL

1 - Name the main components of the ARTOUSTE III turbo-jet engine.

2 - Explain the thermodynamic operation of the engine.

3 - Name the engine main reference stations.

4 - Give the value of the following performances and characteristics :

- Nominal power on the shaft
- Residual thrust
- Equivalent power
- Specific consumption
- Compression ratio
- Air flow
- Turbine inlet temperature
- Generator shaft rotation speed
- Weight of engine fully equipped.

5 - List all the accessories required for engine operation.

6 - Explain the principle of engine control and fuel flow control.

7 - What are the effects of atmospheric temperature on the performances ?

8 - What are the effects of altitude on the performances ?

ENGINE DESCRIPTION

1 - Draw a schematic diagram of the reduction gear.

2 - Describe the air intake and compressor assembly.

3 - Describe the combustion chamber assembly.

4 - Describe the turbine and exhaust system assembly.

5 - List the bearings supporting the rotating assembly.

6 - Describe the engine internal fuel supply system.

7 - List the accessories mechanically driven by the engine.

8 - What is the meaning of "engine run down time" ?

9 - List the checks and the practices to be carried out on the engine (bare engine) during a periodic inspection.

10 - List the operations permitted in first line maintenance.

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9 - List the checks and the practices to be carried out on the engine (bare engine) during a periodic inspection.

10 - List the operations permitted in first line maintenance.

LUBRICATION

1 - Name the various sections of the engine which need lubrication.

2 - Draw a schematic diagram of the oil pump assembly.

3 - Purpose and operation of the pump pressure relief valve.

4 - Give the location and the type of oil filter.

5 - Purpose and operation of the oil filter by-pass valve.

6 - Explain how the scavenge of the lubricating oil is carried out.

7 - Explain how the air vent of the various lubricating points is carried out.

8 - Explain how the cooling of oil is carried out.

9 - Name the various types of seals used to ensure the sealing of the oil system.

10 - Describe the indicating devices to check oil system operation.

11 - Describe the rinsing procedure of the oil system.

12 - Name the various possibilities of fuel entering the oil system.

13 - List the most likely causes of "abnormal" oil pressure.

14 - List the most likely causes of "abnormal" oil temperature.

15 - List the probable causes of abnormal oil consumption.

16 - Explain how the oil supply to the isochronous speed governor is carried out.

17 - List all the external lubricating pipes, scavenge pipes and air vent pipes.

18 - Name the main limitations (temperatures, pressures, consumptions) of the oil system.

19 - What are the operations to be carried out on the oil system during a pre-flight inspection ?

20 - What are the operations to be carried out on the oil system during a periodic inspection ?

FUEL SYSTEM

1 - Schematic diagram of the aircraft fuel system.

2 - Schematic diagram (block diagram type) of the engine fuel systems.

3 - List the accessories of the ignition fuel system.

4 - Purpose of the fuel draining through the micro-pump.

5 - Schematic diagram of the four way union.

6 - Schematic diagram of the ignition coil.

7 - Purpose of the torch-igniter ventilation.

8 - List the various phases of operation of the ignition fuel system.

9 - Schematic diagram of the main fuel pump assembly.

10 - Explain the purpose and the operation of the fuel pump pressure relief valve.

11 - Purpose of the fuel pump by-pass calibrated orifice.

12 - Purpose and operation of the throttle fuel valve.

13 - Schematic diagram of the barostatic idling device.

14 - Explain the operation of the idling device.

15 - Purpose and operation of the starter cut-out switch.

16 - Purpose and operation of the starting valve.

17 - Explain the operation of the electric fuel cock.

18 - Draw a curve illustrating the operation of the system during starting.

19 - List all the adjustments of the fuel system components . (give the function and the procedure of each adjustment).

20 - Name the operations to be carried out on the fuel system during a periodic inspection.

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19 - List all the adjustments of the fuel system components . (give the function and the procedure of each adjustment).

20 - Name the operations to be carried out on the fuel system during a periodic inspection.

AIRCRAFT SERVICES

1 - Describe the engine attachment system.

2 - Indicate the characteristics of the air which is at the aircraft manufacturer's disposal.

3 - Characteristics of the accessory drive at the aircraft manufacturer's disposal.

4 - Purpose of the spare drive.

5 - Describe the mounting system of the exhaust pipe.

STARTING

1 - List the components involved in engine starting.

2 - Explain how the cranking of the rotating assembly is carried out.

3 - Draw a schematic diagram of the ignition coil.

4 - Explain the operation of the ignition coil.

5 - Draw a schematic diagram of the starter cut-out switch.

6 - Name the various phases of operation of a starting cycle.

7 - Draw a schematic diagram showing the starting sequences.

8 - What are the functions of the starting automatic control box ?

9 - Indicate the main limitations concerning the starting.

10 - Explain what is the "engine ventilation" and how it is carried out.

11 - List the operations to be carried out on the "starting components" during a periodic inspection.

ELECTRIC SYSTEM

1 - List the engine indicating main electrical components.

2 - List the electric accessories involved in starting.

3 - List the main components of the automatic control box.

4 - Function of the safety microswitches in the electric system.

5 - Purpose of the electric fuel cock limit-switches.

6 - Draw a schematic diagram of the starter cut-out switch.

7 - Purpose of the micro-pump microswitch.

8 - What is the function of the lights indicating start and stop sequences ?

9 - Draw a schematic diagram of a time-delay switch.

10 - Purpose of the time-delay switches in the automatic control box.

11 - What is the function of the auxiliary contacts of the starter relay ?

12 - Draw a diagram illustrating the various phases of operation of the starting cycle.

13 - Explain the operation of the electric system during the various sequences of starting, stopping and ventilation.

14 - List all the possible adjustments of the electric components.

15 - List the operations to be carried out on the electric system during a periodic inspection.

16 - Undertake a fault analysis of all the engine electric accessories (search for the symptoms occuring in the case of non-operation of an accessory).

17 - Proceed to a fault analysis of all the "control and indicating" components (i.e. all the parts of the aircraft manufacturer's control panel).

18 - Fault analysis of all the components of the automatic control box.

ELECTRIC SYSTEM

1 - List the engine indicating main electrical components.

2 - List the electric accessories involved in starting.

3 - List the main components of the automatic control box.

4 - Function of the safety microswitches in the electric system.

5 - Purpose of the electric fuel cock limit-switches.

6 - Draw a schematic diagram of the starter cut-out switch.

7 - Purpose of the micro-pump microswitch.

8 - What is the function of the lights indicating start and stop sequences ?

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17 - Proceed to a fault analysis of all the "control and indicating" components (i.e. all the parts of the aircraft manufacturer's control panel).

18 - Fault analysis of all the components of the automatic control box.

AIR SYSTEM

1 - Purpose of the torch-igniter ventilation system.
2 - Draw a schematic diagram of the torch-igniter ventilation system .
3 - Effects of the P2 air taken on engine performances.
4 - List the various fuel draining circuits.
5 - List the filters installed on the various air circuits.
6 - Indicate the operations to be carried out on the various air circuits during a periodic inspection.

ENGINE CONTROL

1 - Purpose of the throttle fuel valve control lever.
2 - Draw a schematic diagram illustrating the various positions of the control lever.
3 - Indicate the various positions (communications established) of the throttle fuel valve relatively to the various positions of the control lever.
4 - Name the microswitches actuated by the lever.
5 - Indicate the function of the control lever microswitches.
6 - Name the switches used to control the engine.
7 - What is the function of the booster pump switch ?
8 - Explain the general principle of engine control.
9 - Name the operations to be carried out on the control systems during a periodic inspection.
10 - Indicate the main operating instructions of the control lever.

ENGINE INSTRUMENTATION

1 - List the various engine instruments.
2 - Describe the t 4 temperature indicating system.
3 - Draw a schematic diagram of the t 4 temperature indicating system.
4 - Describe the rotation speed indicating system.
5 - Describe the oil pressure indicating system.
6 - Draw a schematic diagram of the oil pressure transmitter.
7 - Describe the oil temperature indicating system.
8 - Name the various engine warning lights and indicating lights.

FUEL FLOW CONTROL

1 - Indicate the main functions of the "fuel flow control" in a gas turbine engine.
2 - Explain the general principle of the ARTOUSTE III fuel flow control.
3 - Draw a schematic diagram of a speed governor hydraulically assisted.
4 - Describe the isochronous speed governor.
5 - Purpose of the damping device of the isochronous speed governor.
6 - Explain the operation of the isochronous speed governor.
7 - Draw a curve illustrating the rotation speed variations in the course of time during a load variation.
8 - Check-out procedures of the speed governor operation.
9 - Effect of the oil temperature on the governed speed.
10 - List all the adjustments of the speed governor (indicate the purpose, the effect and the procedure of each adjustment).

NOTES

MAINTENANCE

1 - List the main operations to be carried out during a pre-flight inspection.

2 - List the main operations to be carried out during a periodic inspection.

3 - List the main tests and checks to be carried out during a ground run test.

4 - Indicate the main operating limitations.

5 - Indicate the special precautions to be taken in case of operation in sandy or salty atmosphere and in cold weather.

6 - Explain (briefly) the engine inhibiting and storage procedure.

7 - Explain the procedure of compressor field cleaning.

8 - List the main important operations permitted on engine in maintenance routine.

9 - Explain (briefly) the procedure of removing and installation of the rear bearing (mention only the essential points).

10 - Explain the procedure of removing and installation of the output shaft "sealol" seal.

11 - Explain the oil system draining procedure.

12 - Explain the oil system rinsing procedure.

13 - Explain how the oil pressure indication can be checked.

14 - Indicate the oil pressure adjustment procedure.

15 - Indicate the methods to detect the presence of fuel in oil.

16 - List the various possibilities of passage of fuel into oil.

17 - What are the steps to be undertaken and what are the main causes in case of abnormal oil pressure ?

18 - List the various possibilities of internal oil leak.

19 - List the possible causes of abnormal oil temperature.

20 - Explain the method to bleed the fuel system.

21 - Explain the method to check the sealing of the fuel system.

22 - List all the filters of the fuel system.

23 - Adjustment procedure of the fuel pump by-pass.

24 - Adjustment procedure of the starting fuel valve.

25 - Adjustment procedure of the idling device.

26 - Name the causes of abnormal t4 during starting.

27 - Adjustment procedure of the max. rotation speed.

28 - Adjustment procedure of the isochronous speed governor scroll.

29 - Adjustment procedure of the t4 line resistance.

30 - List the most likely causes of rotation speed oscillations.

31 - List the probable causes of "abnormal" vibrations.

32 - Explain the method to check the operation of starting accessories by simulated starting.

33 - Fault analysis. (The analysis consists, for each component, in searching the symptoms resulting from a fault considered. Such an analysis has to be carried out for every engine component and accessory).

EXAMPLE

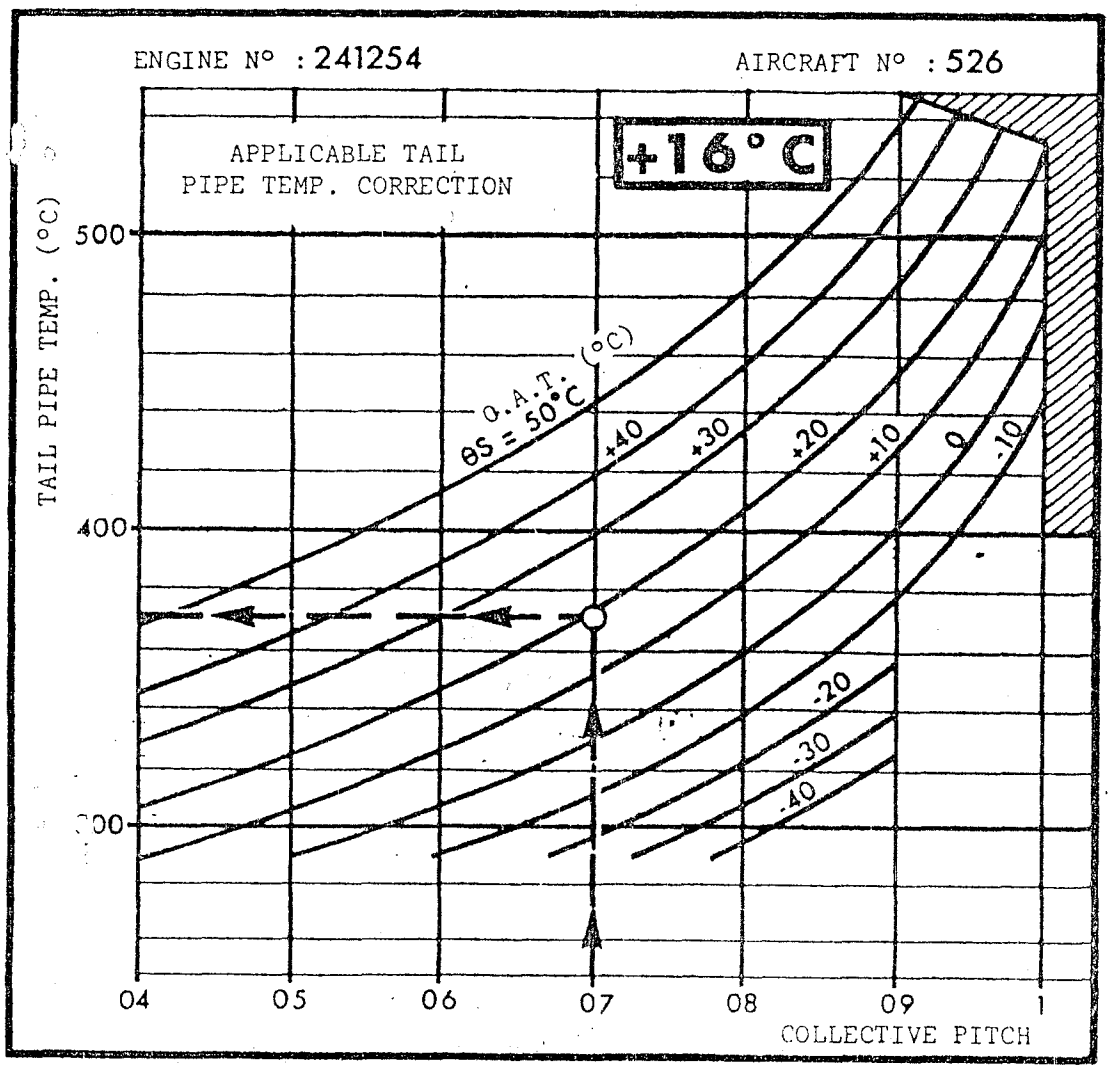
1) Values recorded in hovering flight at 1.5 m from ground :

   a. on O.A.T. indicator (under shelter) + 19°C
   b. on collective-pitch indicator 0.7
   c. on tail pipe temp. indicator 380°C

2) After landing :

   a. Apply to the recorded tail pipe temperature the applicable correction specified on the chart above the instrument panel, e.g. :
   380° + 16° = 396°C
   b. Read on the chart the tail pipe temp. corresponding to the collective pitch and O.A.T. values recorded in hovering flight, i.e. for 0.7 collective pitch and + 19°C ..... 370°C
   c. Determine the difference ..... 396°C - 370 = 26°C.

The difference being less than 40°C, engine power is correct.

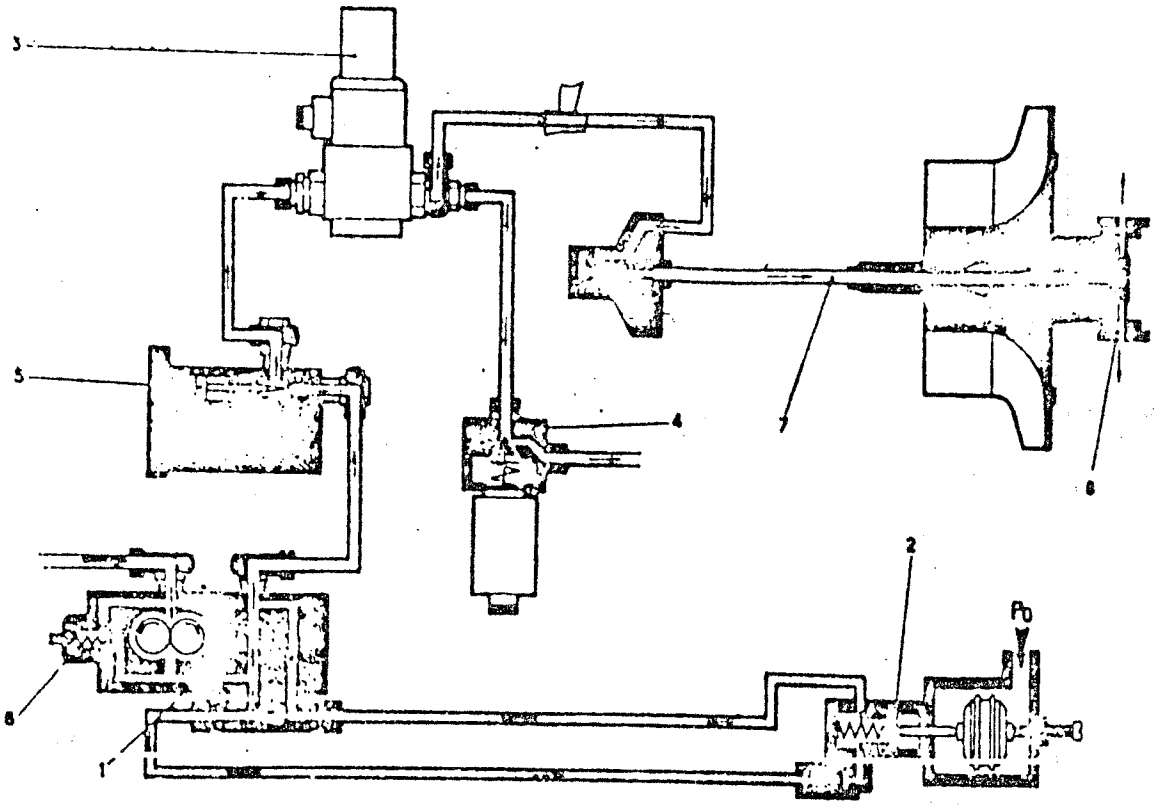


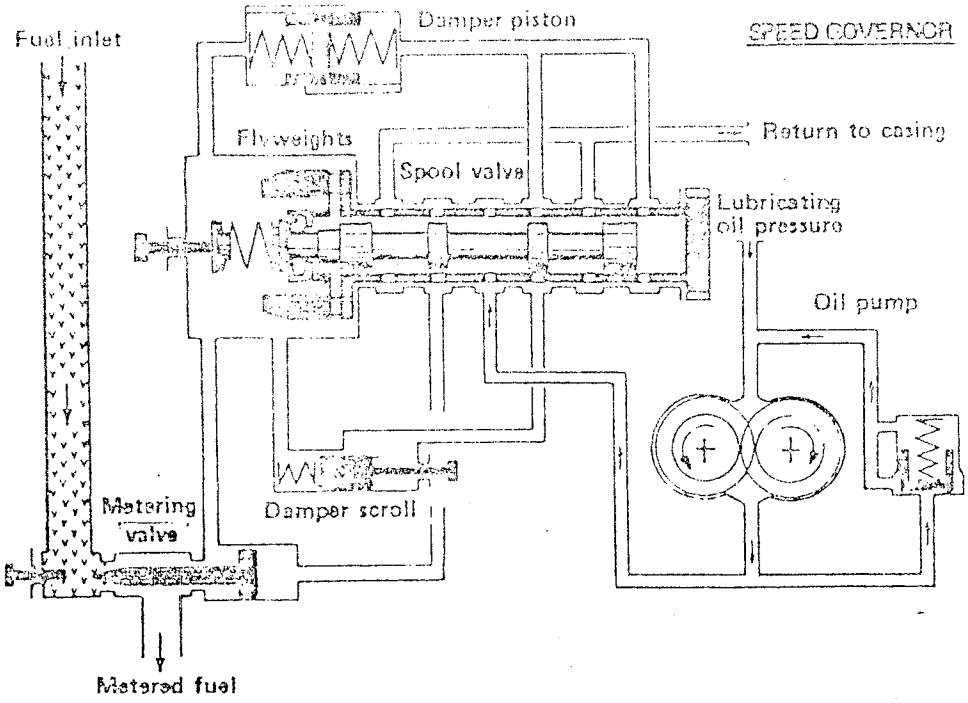
Hovering flight power check

the metering valve positions itself in such a way that the ending of the fuel supply cock (1) opening action has no effect upon the turbine rotation speed.

Normal Operation

When the fuel supply cock is fully open, the quantity of fuel which can flow through it, is larger than this quantity necessary to ensure a full power operation of the engine. In these conditions, governor metering valve (5) positions itself in such a way that the turbine speed remains constant whatever be the load applied to this turbine.





SPEED GOVERNOR SCHEMATIC DIAGRAM

Pressure

Closing

Opening

Return

Fuel (pump pressure)

Metered fuel