	Data	Signatures	
Author: Celso Monteiro	20/03/2020		Title: **Emergency Automatic Respirator Specification Preliminary**
Verif.:			
Aprov.:			

1. Scope

The scope of this document is to provide specifications for the development and prototyping of an emergency respirator.

This equipment is targeted at emergency treatment of CoVid-19 AKA “Coronavirus” as a part of “Open Source COVID19 Medical Supplies”effort.

[PTBR] O objetivo deste documento é prover especificações para o desenvolvimento de um respirador emergencial que possibilite rápida prototipação.

[PTBR] Este equipamento tem como objetivo prover tratamento emergencial respiratório no combate ao CoVid-19, também conhecido como Coronavirus. Esta iniciativa é parte do esforço “Open Source COVID19 Medical Supplies”.

2. Document Control

- 20/03/2020: added portuguese version in some comments, noted as [PTBR].
- 20/03/2020: initial sketch credits to Antonio Rico
- 20/03/2020: added missing hardware and software specifications
- 20/03/2020: Initial release: “RDSV200320 Emergency Automatic Respirator - Premiminary Specification R00”

3. References

- Open Source COVID19 Medical Supplies facebook: https://www.facebook.com/groups/670932227050506/

- COVID-19 Air BRASIL - Fast production of assisted ventilation devices https://www.facebook.com/groups/235476464265909/

4. Initial Considerations

As of March 19, 2020 the world is under what is being considered as the world’s most dangerous virus since “Spanish Flu” back in 1920.

The most affected people need auxiliary respiratory devices typically from periods of 2-3 weeks and many ICUs at hospitals can’t afford it. At this moment there are some places that are denying medical assistance to some groups of citizens due to absence of this equipment.

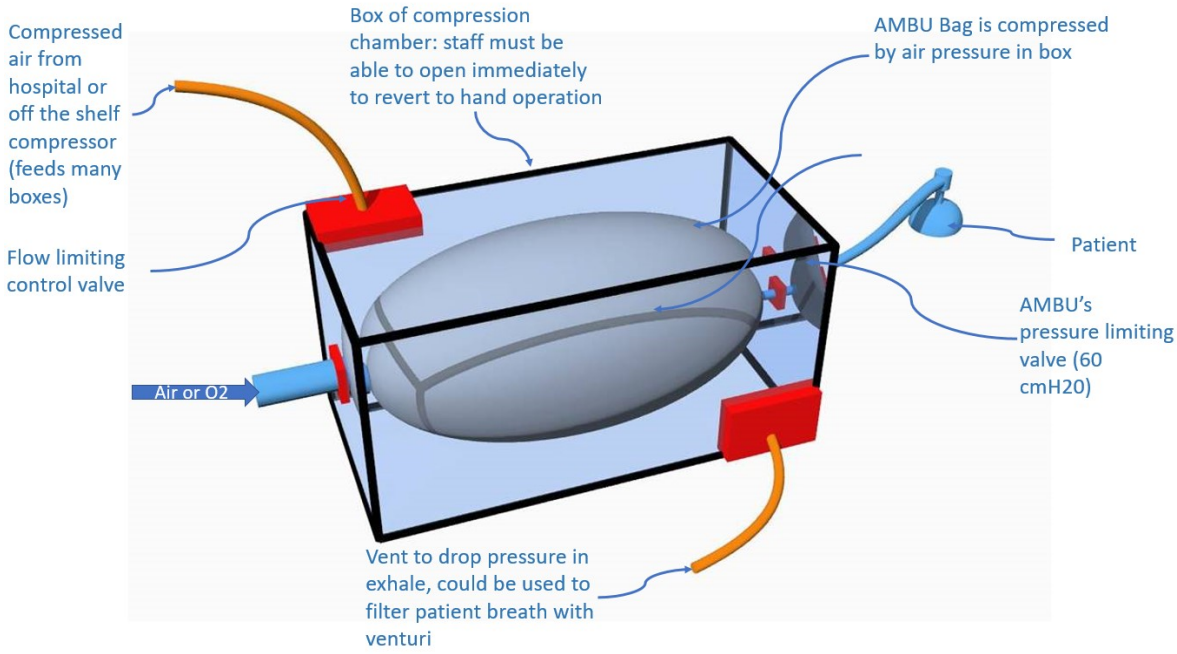
Globally speaking some groups were formed to work as volunteers to help in this situation. One group is the “Open Source COVID19 Medical Supplies”.

This specification is attached to the initiative of Joannes Berque: COVID-19 Emergency Solutions - DESIGN AND PRODUCTION OF AN AUTOMATED AMBU COMPRESSOR
A Solution to Relieve Staff Requirements for Mechanical Ventilation.

The initial concept from Joannes Berque was quite simple: it was an Automation of a Classic AMBU aka ACA.

The ACA project is a computer controlled respirator which is basically an AMBU inside a box where we change pressure simulating manual operation to control patient respiration. There is a compressor, a vaccum pump and some valves to control the airflow. The original AMBU air valves remain unchanged.

Pressure inside the box is monitored by a pressure sensor. The CPU reads this sensor in order to fine control the respiratory cycle.



Original sketch by Antonio Rico

[PTBR] Na data de 19 de março de 2020 o mundo está passando pelo que tem sido considerado o vírus mais perigoso do mundo desde a "Gripe Espanhola" de 1920.

[PTBR] As pessoas mais afetadas necessitam de equipamentos respiratórios durante um período de tipicamente 2 a 3 semanas e muitos hospitais não os disponibilizam na quantidade necessária. Neste momento já existem lugares onde hospitais selecionam pacientes a serem tratados por falta de equipamento.

[PTBR] Globalmente falando, alguns grupos se formam espontaneamente para trabalhar voluntariamente. Um destes grupos é o “Open Source COVID19 Medical Supplies”, que já tem um grupo local formado no Brasil.

[PTBR] Esta especificação é aderente à iniciativa de Joannes Berque: "COVID-19 Emergency Solutions - DESIGN AND PRODUCTION OF AN AUTOMATED AMBU COMPRESSOR
A Solution to Relieve Staff Requirements for Mechanical Ventilation."

[PTBR] O conceito inicial de Joannes Berque é muito simples: se trata da automação de um AMBU clássico, denominamos de ACA.

[PTBR] O projeto ACA é um respirador controlado que é basicamente um AMBU dentro de uma caixa onde através da mudança da pressão da caixa simulamos uma operação manual respiratória em um paciente.

[PTBR] A pressão interna da caixa é monitorada por um sensor de pressão. A CPU lê este sensor para poder ter um ajuste fino do ciclo respiratório gerado.

The respiratory cycle could be described by this sequence of actions:

- The box relief valve is opened allowing bag to come closer to local atmospheric pressure. O2-enriched air intake valve is mechanically opened and bag is full of O2 enriched air. Patient exhales thru AMBU mechanical relief valve. The exhaust gas is collected, possibly barrier filtered and returned to ambient (is sterilization necessary?)

- The box relief valve is closed, compressed air valve is opened so the bag is pressurized producing airflow into the patient. Final box pressure is controlled and it defines the quantity of supplied air. Accidental overpressure due to a malfunction is limited by existing AMBU pressure limiting valve.

Future reviews should include assisted operation, where the system should wait for patients breathing to start, applying assisted breathing. Possibly it will add an extra pressure sensor to check patient’s diaphragm movements.

[PTBR] O ciclo respiratório poderia ser descrito por uma sequência de ações:

> [PTBR] - A válvula de alívio da caixa é aberta permitindo que a pressão atinja a pressão atmosférica local. A válvula mecânica do AMBU abre a bolsa se enche de ar enriquecido com O2. O paciente expira através da válvula mecânica do AMBU. A expiração é coletada, possivelmente filtrada por um filtro de barreira e retornada ao ambiente (precisa esterilizar?)
>
> [PTBR] - A válvula de alívio da caixa é fechada, a válvula de entrada de ar comprimido é aberta comprimindo a bolsa do AMBU e produzindo fluxo de ar para o paciente. A pressão final da caixa é controlada e isto define a quantidade de ar fornecida. Pressão excessiva acidental por funcionamento defeituoso é restrita por uma válvula limitadora de pressão do próprio AMBU.

[PTBR] Revisões futuras devem incluir operação assistida. Neste modo o ACA deve esperar pela inspiração do paciente e após isto aplicar respiração assistida. Possivelmente será adicionado ouro sensor de pressão para verificar os movimentos do diafragma do paciente.

5. Specification

5.1. Hardware Specification

Inputs:

- Pressure sensor: MPN TBD 0-5V range
- Potentiometers for setting Period and Pressure, linear 10Kohms maximum, ends connected to +5V and GND, wiper produces 0-5V range output signal

Outputs:

- General: All outputs, except if otherwise specified, are low side driven and whenever possible with short circuit protection
- Box relief valve A: solenoid valve, MPN TBD, Valve Voltage: X (TBD), maximum current: Y (TBD)
- Box relief valve B: same as A, operated in parallel with A thru individual controls)
- Compressed Air Valve C: solenoid valve, MPN TBD, Valve Voltage: X (TBD), maximum current: Y (TBD)
- Compressed Air Valve D: same as C, operated in series with C thru individual controls
- Malfunction Indicator: led lamp or similar, MPN: Z, maximum current: T (TBD).
- Optional LCD display (TBD), without short circuit protection.

CPU:

- 5 Volt Microcontroller with local availability, able to comply with all hardware and software specifications. First prototype will probably be based on Arduino because of availability and huge base of developers. External watchdog timer (not MCU built-in) is recommended to increase reliability.

PSU:

- ACA power supply: 12V or 24V (TBD) Amps. It should guarantee 9-16VDC (12V system) or 18-32V (24V system) in worst case scenario. If primary AC source is used, double isolation PSU is required.

5.2. Software Specification

ACA needs to provide all the functions below:

- Timed Valve Control, within programmed periods. User defines period based on potentiometer position 50% course should be most frequent use. Maximum course should be set to 25% - 75% range. Readings in ranges of 0-25% and 75-100% should perform as expected but also it should be reported as malfunction.

- Max pressure applied to patient, within programmed periods. User defines period based on potentiometer position 50% course should be most frequent use. Maximum course should be set to 25% - 75% range. Readings in ranges of 0-25% and 75-100% should perform as expected but also it should be reported as malfunction. Access to this pot should be restricted to avoid accidental misuse.

5.3. Environmental specification

Operational Temperature: 10-50C (TBD)
Altitude: TBD

5.4. Compliance

ACA should be designed to meet all local requirements for this kind of equipment. Probably the equipment will not be certified due to urgency but it should be at proper time.

For Brazil:

- Designed to comply with TBD (ANVISA, INMETRO, …)
- EMI compliance to TBD (CISPR, …)